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AWARD WINNER MISPLACED

New York University's Robert Ewald Treybal, winner of the Twelfth George Westinghouse Award, was erroneously identified with the faculty of another institution in the October issue of the Journal. The Editor wishes to express apologies both to Professor Treybal, and to NYU.

Now Professor of Chemical Engineering, Dr. Treybal received his initial appointment at NYU as an Instructor in 1937. He has since taught many graduate and undergraduate courses, directing numerous investigative theses, and has served on most of the major committees of the College of Engineering. He is the author of two important books, *Liquid Extraction* and *Mass-Transfer Operations*, as well as many technical articles.

56-YEAR MEMBER RETIRES

Professor Almon H. Fuller retired recently from his post as Head of the Civil Engineering Department of Iowa State College after a distinguished career of 60 years in Engineering Education. The Iowa Board of Regents has conferred upon him the honor of Professor Emeritus.

Dr. Fuller's 56-year membership in the ASEE is one of many professional affiliations, including eight honorary memberships and degrees. His published works include journal articles and several books, the most recent being the forthcoming "History of Civil Engineering at Iowa State College."

A consultant and structural designer, Dr. Fuller now resides at Wesley Gardens, Des Moines, Washington.

DO YOU KNOW . . . .

► . . . . That the Committee on Development of Engineering Faculties is preparing a booklet designed to interest students in teaching as a career? Publication should be in late winter. The same general theme is being suggested for the YET Paper Contest this year. CDEF also has written all engineering deans urging them to bring to the attention of seniors the wisdom of considering a career in engineering teaching. There must be rewards for engineering teaching—or why have you and the other good men stayed in it?

► . . . . That CDEF has distributed a report on "Salaries and Earnings of Engineering Teachers—1956" to all deans of engineering? It is a comprehensive analysis of data, originally collected by Engineers' Joint Council, with respect to people in the field of engineering education. Copies may be purchased from the office of the Secretary for $0.25 each. The same is true of "Engineering and Scientific Manpower Problems—An Annotated Bibliography."

► . . . . That the summer institutes on nuclear energy jointly sponsored by AEC and ASEE will be repeated next summer? Three basic institutes, three or four of an advanced nature, and one for technical institute instructors are planned. A preliminary information sheet already has been sent to deans of engineering. Present plans are to have an educational institution conduct the programs with the active cooperation of an AEC laboratory. By 1960 it is hoped universities can offer all the necessary programs and the need for AEC aid will no longer exist.

The success of these programs is indicated by the fact that thirteen faculty members who took the basic course the first year returned for an advanced course, and ten of the sixty attending the Argonne institute in 1956 participated in that laboratory's summer employment programs in 1957. Many also worked in other nuclear programs, in both AEC and industry.

► . . . . That copies of *Recruiting Practices and Procedures* may be purchased for distribution to students at a special price of seven cents each? Orders should be placed with the Secretary's office. Publication in student engineering magazines also is being encouraged.

► . . . . That copies of the JOURNAL OF ENGINEERING EDUCATION are available for student use at a special rate? Members of faculty-sponsored discussion groups may obtain the JOURNALS for a year (except the *Yearbook*) for $1.50. The sponsor merely submits the names, including year in college, and the money; the JOURNALS are then sent to him in one package. This is another plan to interest students in engineering teaching as a career.

► . . . . That an increasing percentage of college graduating classes is going into teaching? This is the important conclusion of "Summary of the 1957 Teacher Supply and Demand Report" prepared by the Research Division of the National Education Association. The per cent increase for 1957 is estimated at ten. Perhaps teaching does have a growing appeal for young people!

► . . . . That you shouldn't forget about the three mid-winter meetings of the Society? The College-Industry Conference of RWI is at the University of Michigan, Ann Arbor, on January 30–31; the Co-op Division has its meeting at Dallas, Texas, on January 9–10; and the Drawing Division meets at the General Motors Institute, Flint, Michigan, on January 15–17.

► . . . . That one-third of the 2,000,000 Korean veterans who made use of their veterans' training benefits have sought professional, semi-professional, or technical education? The Veterans' Administration reports that 8% entered engineering courses, 2% science, and 3% medicine. Almost as many took electrical engineering, 37,902, as all other branches of engineering combined.

► . . . . That France produces only 90 engineers per million of population against 195 for the U. S. and 236 for the Soviet Union? These figures come from the Newsletter of the President's Committee on Scientists and Engineers. To improve the situation, France is considering a broad plan to democratize and modernize her school system. A major goal is the education of more scientists and engineers.

More than half of all French students entering higher education go into the classics and humanities, largely because these subjects enjoy greater prestige. The Government hopes to direct more students toward technical careers by, among other measures, expanding the technical colleges which prepare students for higher technical education, and encouraging children of workers and lower-middle-class families to seek higher education through scholarships.

► . . . . That the following comments are mentioned for what they are worth? It has been reported that at a conference on the role of research in academic institutions the remark was made (letter is on file) that faculty be paid an annual salary for doing research and then be permitted to take time off from research to teach; a letter from Information for Industry, Inc. states, "30¢ of every research dollar is wasted in duplication"; a NSF news release states, "Funds for basic research in the natural sciences—physical and life sciences—for 1953 in the United States totaled $435 million. This was 8 per cent of the estimated total of $5.4 billion for research and development or about 0.1 per cent of the gross national product of $363 billion. Colleges and universities were the principal performers of basic research, accounting for $205 million or 47 per cent of the total." 1953 is the latest year for which factual data are available.

► . . . . That 97 per cent of the research and development carried on in institutions of higher learning is being done in 173, or 15½ per cent, of the nation's 1120 colleges and universities? These are the 1953–54 figures as reported in "Reviews of Data on Research and Development," published by NSF. Of the $285 million worth of research for 1953–54, federal agencies supported more than half the total, with the Department of Defense contributing more than any other agency. The physical sciences were the chief beneficiaries, and engineering received more than any other discipline in the physical science category.

W. Leighton Collins
Secretary

STUDENT-TO-INSTRUCTOR RATIO

Methods of Meeting the Enrollment Crisis

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Recommended by the Educational Methods Division.

Rapidly increasing enrollments, which threaten to reach astronomical numbers by the seventies (9), are confronting administrators and teachers alike with the ingredients of a first-class educational disaster unless some radically new attack can be made upon the problem. The situation is not unique to the engineering field; it spreads throughout the entire academic structure.

One has only to pause in any faculty gathering to hear the pros and cons of the constant topics of discussion—new staff, new buildings, and the where-with-all to produce them. Engineering, fortunately or unfortunately (depending upon whether you are an expansionist or a hold-the-line advocate), through the successful campaign waged over the last five years, has raised a multitude of boys and girls who are planning their future around the profession.

And now, because of outmoded ideas, we find ourselves in the unenviable position of having to devise ways and means of keeping them *out* of the profession they were wooed to enter, and all because we cannot determine how to accommodate them in our higher educational system. It is ironic that this should occur when even the man on the street knows that the safety and future of our country rests upon the production of more and better engineers and scientists.

One befuddled old character who turns up more and more as the topic of conversation at faculty get-togethers is that slightly tarnished symbol of academic prestige—the student-faculty ratio. Today one rarely attends a departmental meeting where either it or its assumed companion, class size, are not the center of heated discussions.

A glance at some of these student-faculty ratios (11, 16) will reveal several items of interesting information. In Table 1 it becomes apparent that the basis upon which the ratios are computed varies somewhat among the different schools. Table 2 shows the ratios for a group of arts and science colleges. Table 3 give the ratios for some of the technical institutions. One of the paramount difficulties in any computation of this type is the determination of the "average" basis of comparison. Since the various universities include different groups of individuals in their computations and reporting, considerable variation is apparent.

Wide differences may even occur from division to division within the same university. Table 4 shows an example of this. Only the faculty count is given for Harvard, while for the University of California lecturers,

TABLE 1

THE STUDENT–FACULTY RATIO

UNIVERSITIES AND LARGE INSTITUTIONS

	1954	1955	1956		1954	1955	1956
*Harvard	3.4	3.3	3.1	*Ohio State	11.8	14.3	19.5
Chicago	6.1	6.5	7.0	Stanford	11.9	11.7	11.7
Princeton	7.6	7.5	7.5	Michigan	13.8	17.7	17.1
Columbia	7.8	7.6	7.5	UCLA	13.9	12.7	12.2
Pennsylvania	8.8	11.3	9.1	*Minnesota	14.5	—	—
Purdue	8.8	9.3	12.5	Michigan State	15.5	15.1	15.0
Yale	8.9	8.3	7.8	UC Berkeley	15.5	16.3	16.9
New York Univ.	9.8	9.6	9.6	Washington	15.5	14.8	12.1
North Carolina	10.1	11.0	13.6	Indiana	15.7	16.3	16.5
Cornell	10.4	9.4	10.0	Northwestern	16.8	16.0	16.4
Penn. State	10.4	11.0	11.1	USC	16.9	18.8	17.1
*Illinois	11.3	12.5	12.4	Wisconsin	17.3	16.9	17.7
Iowa (St. U. of)	11.7	12.4	12.4	Oregon	17.6	19.6	20.2

* Please note that Harvard ratios are based on a count of *all* faculty, including part-time; other ratios are based on a count of *full-time* faculty. Ohio State ratios are based on approximate figures; Illinois and Minnesota ratios for 1954 are based on figures furnished by these institutions. No figures are available for Minnesota for 1955.

associates, assistants, teaching assistants, and other officers of instruction are included. However, when the Schools of Medicine, Nursing, and Public Health, as well as supervisors in Education, Physical Education, Social Welfare, and Institute and Bureau full-time employees and teaching assistants are removed, the ratios for the Los Angeles campus change to:

	1954	1955	1956
U. C. Los Angeles	19.8	20.9	21.0

This range, unstable and unreliable as it may be (depending upon what factors are added into its computation), may vary just as greatly from department to department within a university. This can readily be seen in Table 5, which gives the existing ratios of the departments within the University of California for the Fall of 1955–56.

TABLE 2

COLLEGES OF ARTS AND SCIENCE

School	1954	1955	1956
Haverford	8.3	8.6	9.1
Amherst	8.6	9.1	10.1
Williams	9.0	8.2	8.5
Reed	9.9	10.5	10.3
Swarthmore	10.4	10.4	9.7
Oberlin	11.0	10.2	11.5
Pomona	11.0	11.5	11.6
Carleton	11.4	11.0	11.4
Knox	12.7	11.9	12.2
Antioch	17.8	17.3	19.7

TABLE 3

STUDENT–FACULTY RATIO FOR SOME TECHNICAL INSTITUTIONS

School	1954	1955	1956
Cal Tech	6.2	5.7	3.1
Case	6.5	7.8	7.8
MIT	8.3	8.4	8.4
Rensselaer	9.9	10.9	10.5

TABLE 4

School	1954	1955	1956
Harvard	3.4	3.3	3.1
U. C. All Campuses	7.2	7.3	7.4
U. C. Berkeley	8.2	8.7	8.8
U. C. Los Angeles	8.6	8.3	8.4

It is disturbing to think that figures used as the basis of so many comparisons are so incompatible because of variations in the method of the count upon which they are made. At first thought it might seem desirable to appoint a committee to see if a comparable basis could be worked out that could be applicable to all schools.

Unfortunately, the number itself is only one small part of the story (an aspect, it must be admitted, that is useful in confusing legislators and others when asking for budgets, developing space requests, and other administrative details), as many a harried professor will be the first to point out. It is probably the parameters affecting this ratio that completely confuse the issue and conceal the true state of affairs in any given institution.

It is very easy to see that in two engineering colleges having exactly the same student-faculty ratio, the actual load carried by the individual teacher could vary greatly, depending upon such factors as size of classes, number of classes, extent of the curriculum, amount of advising, number of graduate students, amount of research, amount of public service, etc.

The important consideration then is not the ratio of students to faculty, but the factors that contribute to the work load of the professor and how they can be reduced. What we need to consider, seriously and carefully, is how we can maintain this work load within reason while still meeting the educational needs of the country.

If this problem is not resolved successfully within the very near future, with little imagination one can visualize the universities falling more and more into the pattern of the high school—surrendering their research functions to industry and assuming the routine role of teaching. Some authorities (15) state that the college professor has been losing prestige steadily since the twenties. If this decline is allowed to continue, it will be impossible to attract any but the mediocre into the profession even though the salary pattern were to become attractive.

The problem that I undertook to review for this paper presents little difficulty when the ratio alone is considered. However, the ratio itself is relatively unimportant; it is the parameters of this ratio that present the difficulties to engineering education.

TABLE 5

VARIATION IN STUDENT–FACULTY RATIO* AMONG DEPARTMENTS OF THE UNIVERSITY OF CALIFORNIA

Department Fall, 1955–1956	Student-Faculty Ratio	
	Dept.	Range within Dept.
Agriculture	4.1	0.3–11.4
Arts	13.2	7.1–15.2
Biological Sciences	17.9	5.9–37.3
Engineering	11.6	6.3–17.2
Languages and Literature	22.3	4.9–75.0
Physical Sciences	27.3	6.7–39.3
Professions	19.5	3.8–26.6
Social Sciences	31.0	—

*Ratio computed from full-time equivalent students and faculty, including lecturers, teaching assistants, associates, instructors, and professors of all ranks.

Basically, what we need is an all-out technological attack upon the problem of engineering education.

The challenge is just as great as that which existed when man moved from the handicraft to the factory system of production. Perhaps under the pressure of numbers we will see an educational revolution that in its own way will be as great a boon to man as the industrial revolution has been to our civilization.

Engineering has a need, a need to develop a method of higher education that will enable it to meet the educational needs of the country. How can this be done? In part it can be achieved by developing a brand new concept of education and the transmission of knowledge and in part, by analyzing the methods that have been advocated by those who have tried to find ways of alleviating the rising number of students and the declining number of scholars.

What then are the methods that have been suggested as ways to alleviate, not cure, the situation? Very roughly they may be grouped under four general headings: (1) those that pertain to the student, (2) those that relate to the teacher, (3) those that relate to the curriculum, and (4) those that relate to classes. While all are inter-related, and all have been considered to some extent by serious students of the problem it is amazing that there exists such a small amount of useful material on these topics. Let us briefly consider some of the suggestions related to these areas:

The Engineering Student has traditionally been admitted to colleges of engineering on the basis of graduation from high school and a statement in writing requesting admission to the college. With the exception of a rash of activity after the Second World War, relatively few institutions have utilized tests or other selection devices to guide the entering neophyte into a field for which he has the aptitude. When we consider that the failure rate for engineering students is somewhere between 60 to 70 per cent of the entering students (9), we can see what an impact a really sound selection and guidance system could have upon our output of graduates.

Those institutions which use tests and grades for admission purposes have reported some success with tests of the general capacity or specific skill type and with pre-engineering subject grades. It is possible that new avenues of approach must be explored in terms of interest, personality, emotional maturity, and other variables that as yet are extremely difficult to measure (7).

When guidance and selectivity for entrance into a college become based upon aptitude and not upon some form of chance, it becomes necessary to have supplementary educational outlets which can accommodate those who are not admitted to the Engineering Colleges. Selectivity is difficult to maintain unless there is a strong supporting Junior College or Technical Institute in conjunction with the University system.

At the present time it is estimated that only 50 per cent of the upper ten per cent of high school graduates go on to attain a higher education (6). It is important that the field of high school guidance be invaded to assure that these individuals enter the fields for which they are qualified. In the long run, mediocrity of students can be just as destructive as sheer weight of numbers.

Concerted efforts need to be made in the form of liaison with the high schools to assure that the students are well equipped and without need for additional preparatory courses. Much might be gained through moving some of the freshman and sophomore courses into the high school, thus allowing the student to enter more rapidly into his professional training.

Information concerning the use of tests and other selection and guidance procedures could be pooled so that all do not have to go through the same laborious procedures of validating these devices.

The Engineering Teacher becomes our second point of attack upon the problems that beset the colleges. There is some indication that the hairy-eared dwellers of the basements of the ivory towers may not exist in the ecstatic condition that the lay person is apt to assume. It has been pointed out that "In seeking the causes for the disillusionment in engineering teaching, it becomes painfully evident that lack of responsibility and lack of time and opportunity for professional growth were the primary ones" (8).

A glance at Table 6 (11) will show the great variation encountered in academic time allocation. This data was compiled from estimates made by the staff of the University of California as to how their working time was spent. It is fairly evident that teaching constitutes the greater load of the young teacher. This introduces an interesting hurdle for him to master in the pursuit of an academic career when it is remembered that in the majority of universities teaching is not considered as an important basis (or even at all) for promotion (4).

Undoubtedly, some useful information will come from the studies underway concerning the problem of what constitutes good teaching. The various committees which have investigated this problem have indicated that we are woefully lacking in the development of new teaching talent. Too many professors are content to lecture on the output of their own research and ignore the challenge to

TABLE 6

PERCENTAGE DISTRIBUTION OF TOTAL WORK WEEK BY RANKS

Type of Work	Prof.	Assoc. Prof.	Ass't Prof.	Total All Grades Prof.	Instructors	Assistants	All Ranks
Teaching	42	49	55	49	64	97	60
Departmental research	21	19	19	20	15	1	16
Organized research	10	13	11	11	9	1	9
Public and professional service	6	5	4	5	3	—	4
Departmental administration	14	9	7	10	7	1	8
Institutional administration	4	2	1	2	—	—	2
All other	3	3	3	3	2	—	1
Total per cent	100	100	100	100	100	100	100
Number of F.T.E.*	734	604	808	2,146	395	535	3,076

*F.T.E. = Full-Time Equivalent.

facilitate the students' learning (3).

Industrial concerns and some Civil Service organizations are utilizing various lures to attract the brighter students into their service. To mention a few, there is tuition paid for the last year, graduate fellowships, all expenses paid for moving, etc. It is conceivable that the engineering colleges will have to devise competitive attractions to assure that the brightest students remain in the teaching field.

The Engineering Curriculum as taught in the United States, it might be charged, has become steeped in tradition and exhibits little evidence of an attempt to break away from the paths laid down by our forefathers. Practically all of our schools are departmentalized. And it is a sad commentary that many departments repeat the same courses with but slight shifts in the emphasis of the subject matter.

This departmentalization and duplication must unfortunately spread the available instructional staff even thinner. Added to this there is the possibility that even in those colleges which do not have departmentalization there may exist the tendency to please all appetities, thus leading to far too many specialties and specialized courses.

One useful method of improving the work ratio of every teacher would be to scrutinize the course offerings and see what need be retained to assure the student a sound education in the essentials he will need when he enters the enginering field. I cannot help but think of the history of one department in which the new instructors at staff meetings were continuously working to add new graduate courses that they could teach. Today, now that *they have* the courses, they are working just as hard to reduce the teaching load and limit the number of graduate students!

In numerous instances considerable saving in total work load could be made if the matter of course prerequisites were carefully scrutinized. If even a course can be saved here and there, it reduces the total work load. At the same time the question might also be posed as to why basic courses so often are deadly things? Can we package them in such a manner that they will be challenging, attractive, and designed to make the student a partner in this problem of securing an education?

One educator describes such a course organization (13). He suggests that the class meetings be cut to once a week, that the teacher of the organized course consider it as his own small college in which he can discover the assets and liabilities of his students. He would have as assistants a number of juniors, seniors, and graduate students who would work with him in planning the course, aid in the discussions, and lead the individual discussion sessions. He advocates paper-covered books and other aids that would reduce the total cost to the student. In the smaller discussion sessions led by the assistants, questions and problems that were troubling the students could be gathered, and the main lecture theme could be built around these questions.

The Problems That Relate to Classes have occupied much of the time of all faculty members. On the basis of the theme that runs through so many of the articles which are making their appearance in the journals, it is evident that we must begin to make some basic revisions in the concept of what constitutes the ideal class. One

hears much about the class of twenty-five being about right.

It has, however, been pointed out fairly recently that this concept dates back to at least the middle of the third century (5). At that time Rabbi Raba, a famous sage of his era, established the rule, "Twenty-five students are to be enrolled in one class. If there are from twenty-five to forty an assistant must be obtained. Above forty, two researchers are to be engaged." And to think that they had not even invented the lead pencil, much less the typewriter or ballpoint pen!

If we wish to maintain classes of this size, and mind you I am not indicating that we should, we either must devise ways and means of recruiting brilliant young engineers into the instructional field to supply the needed number of instructors, or resort to new methods of instruction which will make it possible to extend the instructor into multiple units. On the other hand, there is the possibility of working toward the very large class by increasing the quality rather than the quantity of instructors.

Considerable research has been done on the use of television as a means of teaching, or of extending the gifted teacher to many more groups of students than he would otherwise be able to handle. Some of the possibilities and problems have been summarized by two groups (10, 12) who indicate that (1) it is possible to produce good results; (2) it is about twice as hard as classroom teaching; (3) it requires greater detailed preparation; (4) it requires more teaching aids and a greater variety; and (5) it works best when the teacher has a live classroom audience.

Some problems which it produces are: (1) Loss of effectiveness of presentation; (2) Absenteeism; (3) It is predominantly a visual medium—the photogenic features of the professor may not be enough to hold the audience; (4) It is difficult to obtain materials that can be reproduced on a small screen; and (5) It is difficult to assure clarity and thoroughness.

Still other investigators have pointed out that we have barely scratched the surface in the use of the motion picture medium in our attempt to solve the class size problem (15).

Throughout this paper I may have given the impression that nothing is being done about these things. Perhaps one of the most encouraging signs is to be found in the inquiries which have come to me from thoughtful engineering educators who have asked questions on the problem of setting up controlled experiments in the educational field, experiments which will in several years give us fairly conclusive information as to whether a particular new technique results in equaling or bettering our normal classroom procedure.

For example, one of two experiments (1, 14) now under way at the University of California, Los Angeles, is designed to determine whether the students can monitor the class entirely without the presence of a teacher. For approximately a three-year period a subject which has been regularly taught by the experimenter will be handled in the following fashion. One section will be taught in the usual manner with the professor in charge. A second section will be taught without the presence of the professor. Specially prepared slides, tapes, etc. will be used in conjunction with care-

fully constructed training examinations. Students in the class will monitor the class.

The experiment is to run approximately three years in order to allow for variations in the scholastic ability of the students, inasmuch as the assignment of a student to either of these sections will be based on the usual procedures. The results of this experiment and others in which engineers are pioneering will, when pooled, not only give us the answers to our problems, but provide the entire educational field with vital information.

Perhaps then what is needed most is to take a good look at the teacher and his role in the modern educational system. Study him and see how he can be developed, extended, and multiplied—not only from the points of view that we have mentioned, but also from the point of view of a great industry, one that has been operating on a handicraft level in a machine age. This might include such unimaginative things as secretaries, administrative help with committees, private offices, recording and dictating equipment, and other things taken for granted by the research scientist in the industrial setting.

Will we ten years from now be following along in the traditions of the third century, or will we be teaching in a modern age of education? The choice is up to us!

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PUBLICATIONS OF INTEREST

Career Satisfactions of Professional Engineers in Industry (84 pp.). A research survey for The Professional Engineers Conference Board for Industry, in cooperation with The National Society of Professional Engineers. Presents views and attitudes of professional engineers in the aircraft, automobile manufacturing, chemicals, electronics, electrical machinery, heavy equipment, petroleum refining, and rubber industries. Available from PECBI, 2029 K Street, N.W., Wash. 6, D. C., at $1.50 to members of NSPE, $3.00 to nonmembers.

Engineering Manpower: How to Improve Its Productivity (162 pp.). A comprehensive study of the practices and policies of American industry that affect the productivity of engineers, conducted by the Graduate School of Business Administration, Harvard University. Available from Engineering Manpower Reports, P. O. Box 161, Cambridge 38, Massachusetts, at $18.50.

Educational Television Program Survey (12 pages). A survey of the nature and growth of educational television programming. Available from Educational Television and Radio Center, 2320 Washtenaw Ave., Ann Arbor, Michigan.

"National Science Foundation: the First Six Years," *Science,* August 23, 1957; Vol. 126, No. 3269, pages 335–343. A review of the development of the NSF and critical appraisal of its activities by Dael Wolfle. Reprints available from Clyde C. Hall, Public Information Officer, NSF, Washington 25, D. C.

Atomic Energy Commission Studies. Fourteen studies in the fields of metallurgy and ceramics, and five studies on instruments were recently released for sale to the public through the Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. Prices vary from fifty cents to six dollars.

Some Ideas On

ETHICAL SIGNIFICANCE IN COLLEGE RECRUITING

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Presented at a Conference of the Ethics Committee, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 20, 1957.

Recommended by the Ethics Committee.

This paper may be two years too late or it may be most timely, depending on what you want to read. If you expect to get a re-hash of the lack of recruiting ethics during the past two years, then the paper is two years too late. If, on the other hand, you are interested in preventive medicine rather than patent remedies, this presentation may yet be in time.

The author's observations and suggestions are based in part on 16 years of engineering college teaching. They are also based on experiences obtained in professional consulting work and on contacts made with hundreds of college graduates of all types and levels in the course of preparing recruiting materials for corporations.

Present Attempts to Approach the Problem

The recurrent rash of gross violations of ethical principles in human relations is well known. There have been too many cases of bonuses for accepting employment, sly winking at double expense accounts, exorbitant entertainment, so-called "restudy" of salary offers, and other abuses. These are so obvious it offends a professional man to think he would even need to suggest they are not proper practice and must be corrected.

This paper will not discuss these well-known ethical errors. Effective action has already been taken by a number of groups in an effort to correct them. The Ethics Committee of ASEE, working jointly with the Midwest College Placement Association, has recently produced a document, "Recruiting Practices and Procedures," a revision of a less elaborate statement of 1949.

The Manufacturing Chemists Association has been active in enlisting the interest of other groups in the problem. Through their efforts cooperative committees are now being set up by the U. S. Chamber of Commerce, the National Association of Manufacturers, and other large industrial groups, to publicize the recommended corrective procedures. The Eastern college Placement Association has a committee working on a document having the same function as the ASEE-MCPA publication.

Recently the Executive Board of ASEE has suggested that the matter be studied by the Engineering College Administrative Council and the Relations With Industry Division. All of these groups, however, may fall into the pitfall of proposing remedies rather than searching for the basic cause of the ailment.

The Basic Honesty of the Student

Former Chancellor Hutchins of the University of Chicago once said that the new college graduate is closer to the truth than he will ever be in his life. The remainder of life is largely one of rationalization, brought on by a process of osmosis in the adult world in which the graduate finds himself. This paper will consider that in the general case the college graduate has the following assets essential to the shaping of ethical principles; he is:

1. Intellectually and morally honest
2. Somewhat fearful of his own limitations
3. Generally eager to become outstanding in his "field"
4. Quite capable of learning and reading at a rapid rate
5. Entirely unfamiliar with a time-clock approach to things of the mind
6. Possessed of a large or small amount of intellectual curiosity, depending on what his *Alma Mater* has done to him
7. Convinced that in a land of free enterprise he will have an opportunity as an individual
8. Deperately anxious to please his superiors in experience or in business position
9. Eager for any word or action that will give him some idea of how he is progressing or, if applicable, regressing.

These young people are more concerned with the big decision of a first job than most recruiters realize. In their search for the truth about a job opportunity, they will ferret out information directly or indirectly, depending on the quality of recruiting materials given them and the skill and honesty of the interviewer. They are more skilled at being interviewed than most interviewers are at interviewing. Now let's look in on a few new facets of this brief tête-à-tête.

Unrecognized Ethical Problems in the Recruiting Process

Except for co-operative work and summer employment, the college graduate gains his first impressions of business and industry from the recruiter. Many of the questions he asks of the recruiter undoubtedly seem silly or picayune to the latter, yet the graduate can ask questions only in relation to the rather limited experiences of his college program.

The first job of the recruiter, therefore, is one of public relations for industry in general. Secondly, it is public relations for his company. The recruiter must realize that of the many students he interviews on campus, only a small number will accept employment with his company; the vast majority will end up with other companies. Under the pressure of signing up warm bodies, this public relations aspect has too often been overlooked. Admittedly, it is a small point, but as the opening one this sets the stage for the remainder of the interviewing procedure.

Should Non-Engineers Interview Engineers? Engineering and science graduates can expect to progress in industry in either their professional field or in management, seldom both. General or specific questions regarding management opportunities can certainly be answered by recruiters having either technical or non-technical training. Questions relative to opportunities offered in the professional fields of engineering and law, for example, can only be answered by a recruiter with similar professional training and experience.

If a company sincerely offers professional opportunity to engineering graduates, and recognizes that the ini-

tial impression is made in the first interview, should it not use engineers to recruit engineers? Admittedly, the new graduate is not a professional, yet he is quite susceptible to guidance toward being one.

The author considers it a violation of professional ethics to recruit engineers with graduates from liberal arts or other programs who have no feel for the professional climate that may or may not exist in the company. Some of the reasons for this will be apparent from other ideas developed in this paper. In the author's judgment, engineering recruiting is a function of engineering management.

This opinion, of course, presupposes that both parties use the on-campus interview to explore professional interests and opportunities. It assumes that time is not wasted "getting acquainted" on matters which should properly have been presented in the company's descriptive literature and the student's qualification records.

The Recent Graduate as an Interviewer. A recruiting technique that has been gaining favor in the past few years is to send a recent graduate back to his *Alma Mater* to solicit interviewees. This young man has generally been out of college for one or two years, is most personable, and probably has not yet been given a permanent assignment.

He is in no position to know what kind of challenge or opportunity the company offers in professional or management work. He can only sell the pitch of "a good company to work for," "nice people to work with," and similar minor points. He makes an emotional sell because he cannot offer a rational judgment of the many factors related to first job selection. Obviously, the professional needs of the individual are deliberately ignored or sacrificed on the altar of expediency.

The Recruiter's Rôle as Vocational Counsellor. Whether they realize it or not, many recruiters are counselling men in the selection of a professional career. The ethical implications are obvious. The recruiter must recognize the great responsibility that faces him in this difficult role. He must be intellectually honest and completely objective, yet he may lose a man in the process. The skilled recruiter will recognize that it is better to counsel wisely and lose a man but make a friend than it is to counsel selfishly and select the wrong man.

Is Your Training Program Good? As the feed-back process works through the co-operative program and alumni visits, engineering students and faculty are securing more and more detailed information regarding industry's training courses. The stereotyped ones are quickly recognized for what they are, while those that are virtually graduate development programs are enthusiastically noted. It is the responsibility of the recruiter to answer honestly specific, detailed questions regarding training courses and the rigor with which they are given. Simple ethical principles of honesty are often violated here.

The Truth of Advancement. Another area requiring complete honesty relates to rate of advancement. Too often clever titles are used to suggest promotions when actually there is no substance in them. Men are given the title of "Manager" when the man and his secretary constitute the department. The private office is often used as a device to suggest advancement without real substance.

While the new graduate may not appreciate all of the fine points involved, the recruiter has the responsibility of telling him of the difference between salary and benefit advancements versus advancements in respon-

sibility, whether professional or management. The latter type depends on individual skill, ability, drive, and other factors and, obviously, will vary considerably. Does the recruiter violate ethical principles when he ignores this and paints a rosy picture of "advancement" that is seemingly as automatic as breathing?

And What of Professional Climate? The professional challenge in terms of the professional climate offered in a company is often misrepresented. This is particularly true in those companies where design is important. Many companies force a man to work on narrow segments of problems for many years before being allowed to participate in broad overall planning and design. Unfortunately, the connotations of "professional climate" * are little understood by many companies and certainly by many recruiters of the usual type.

Whether the college graduate recognizes it or not, professional climate has been an important part of his college training. He has found intellectual reward by sharing ideas with others, by working on student-community activities, and in study beyond that required for class preparation.

He has participated in stimulating discussions in his advanced course work where a man has the opportunity to suggest ideas but where he must defend them. He has burned the midnight oil, attended special lectures, gone to concerts, and done many other broadening things that have planted the seeds of professional potential in his mind *and heart*. It is now his employer's responsibility to nurture these carefully so that they can, with time, come forth fully developed.

These are important factors which the recruiter can present honestly or dishonestly. If they are dishonestly presented and the man accepts employment only to learn the horrible truth, he will leave the employer, bitter toward him and toward the profession. Thus, both employer and profession lose.

This subject is not a matter of the simple ethical relationship of honesty. *It is not ethical for a company to recruit college graduates trained for a profession unless it can give a reasonable number of them an opportunity to develop in that profession or in the management related to it.* This obviously implies that the company's training program must be as rigorous as the man's college training. Supervisors and administrators must, by example, set the pace for continued study, interest in professional societies, concept of professional climate, and generally broad interests in society for the younger men coming into the organization.

Do You Have a Union? What is the ethical responsibility of the company that has an engineer's union in regard to mentioning the situation when interviewing the college graduate? If the concept of industry's ethical responsibility to develop the proper climate for professionally trained people can be accepted, then it must be recognized that the presence of a union would certainly influence such a climate and must, therefore, be mentioned. The fact that the interviewee does not raise the question does not

* Defined by the Committee on Professional Climate of the Relations with Industry Division.—"The conscious attitude of associates and management, integrated to stimulate and encourage increased intellectual capacity of skill and integrity, acquisition of experience, and effective application of skill and knowledge in the conduct of work, and with due regard for service to society and the enhancement of the profession. 'It's a matter of heart as much as of mind.'"

excuse the recruiter from mentioning it to him. The sin of omission can be as bad as the sin of commission.

The Procrastinator. One of the cruelest violations of ethics arises from the recruiter's lack of fortitude to make a decision regarding the employment of a man. Many a student has been invited to visit a company's plant or home office, with the reasonable expectation that he had safely passed the first hurdle and had a chance of employment. Yet, how often such trips merely relieve the recruiter of the responsibility for making the decision in so-called "borderline" cases.

The College's Responsibility

Many of the areas of responsibility previously assigned to industry are shared in a dual rôle by the college. Quickly stated, it is the responsibility of the administration of the college to provide that type of professional climate for the professorial staff that will enable them to see some of the foregoing ethical principles involved in the recruiting process. The faculty and administration, as professional people, *must* be involved. Again, it must be pointed out that the obvious areas of ethical violations in the form of bonuses, expense accounts, and others, are so obvious that they hardly warrant discussion, yet these must be watched by the college.

The administration must be certain that its teaching staff represents a proper balance of academic and professional people. The staff, in turn, must take conscious steps to see that the proper kind of professional climate is developed for students.

Professors must conduct themselves in a professional way in class, in consulting work, and in advising students regarding employment after graduation. These briefly cover the important areas in which the teaching staff can establish principles of ethical conduct. Now, how can some of the industry-college areas of potential violation of good ethical principles be forestalled?

A Suggestion for Departmental Placement

It is proposed that a major corrective step should be taken to make the placement function a part of the academic departments in professional schools. Thus, a Civil Engineering Department would find part-time employment for the summer for its students, place co-operative students with companies, and find professionally acceptable employment for graduates.

It is recognized that this by-passes the traditional responsibility of the placement office. It must be noted, however, that most placement offices are not under the direction of an engineer or other professionally trained person and certainly not under the direction of people trained in all professional fields. Placement people, more often than not, have little or no communication with the faculty.

Most of them can act as little more than a clearing house for information regarding dates of interviews and to distribute recruiting booklets. This is a rather passive role in a process so vital to the student's professional development. It is certain that they cannot police the problems of professional ethics raised in this paper.

It is anticipated that the ethical violations suggested in this paper will become more and more common unless this recommended step is taken in the near future. This is a matter of importance to persons and companies concerned with the professional development of individuals, and thus with the enhancement of their respective professions.

WHAT SOME OF THE COLLEGES ARE DOING ABOUT ETHICS

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Presented at a Conference of the Ethics Committee, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 20, 1957.

Recommended by the Ethics Committee

In its first report to the Society in 1953,[1] the Committee on Ethics (then known as The Committee on the Promotion of Ethical Standards) recommended:

"1. That the faculty of every college or school of engineering be concerned with instruction of all students in general and professional ethics; and with their motivation so that they will comply with ethical standards after graduation.

2. That this concern of the faculty be implemented by such specific and formal measures as may be most appropriate to the traditions, organization and operation of the individual institutions.

3. That promotion of ethical standards in engineering education be recognized as an element in the objectives of ASEE, and that a permanent organization be created, in the Society, and permanent activity undertaken, in order to achieve this objective.

4. That one such activity be the organization of subject matter and reference material for ethics instruction."

Some information was available at that time concerning what was being done in engineering colleges about ethics, but not much, really. Accordingly, the Committee—or more accurately Dean Freund who has done the lion's share of the Committee's work these past five years—began to survey the situation through the medium of letters addressed to each of the engineering deans. A program was then to be worked out, on the basis of the returns, for stimulating the concern of engineering faculties with respect to the teaching of ethics, and for suggesting ways that this concern might be implemented.

A number of excellent reports (and also, frankly, some that were not so good) were received by the Committee—enough to indicate that some very significant attention is being paid to the subject of ethics by an impressive group of schools. Of course, the methods of treatment vary "all over the lot," from formal courses in ethics on the one hand to such indirect influences as faculty behavior on the other. At one time, it was the plan of the Ethics Committee to select some of the most challenging of the programs and report upon them in a series of news letters to the engineering deans. But the plan fell through, and thus the Committee is using this paper to report some of its findings to the Society.

Ethics is taught by engineering colleges in many ways, some by direct methods, even more by indirection. Only a few of the respondents were careful to differentiate between *general* and *professional* ethics. Accordingly, it has not been possible to do so here. Examples are:

[1] "On Engineering Integrity," JOURNAL, December, 1953.

1. "complete," formal courses in general ethics or philosophy;
2. courses in which ethics is treated formally, but with other, usually associated, material;
3. courses in which ethics may be introduced, more or less informally, as the opportunity presents itself;
4. extra-curricular meetings, forums, or seminars in which ethics may be featured or discussed;
5. the intellectual and moral environment of the institution as reflected by educational objectives, faculty behavior, honor systems, etc.

The University of Detroit and Marquette University, both Catholic, are typical of those schools which require formal courses in general ethics of all students. Instruction in ethics at Detroit is given under the heading of "Moral Philosophy" in one of a required sequence of three courses in philosophy. Students at Marquette study "Social Ethics," and some take several additional courses in the theory or application of ethics.

Topics discussed may include: the nature of ethics; the norm and determinants of morality; natural and eternal law; rights and duties of the individual; etc. (Typical syllabi are available on request.) Courses in ethics, and more commonly philosophy, are available at any number of schools on an elective basis, and they are apparently quite popular among those students who have the privilege of some free election in the humanities.

Almost every one of the Committee's correspondents reported that one or more class sessions in a variety of appropriate courses are devoted to lectures or discussions of ethics or ethical problems. This is done at Kanasas State College and Northeastern University, for example, in required senior courses in "Professional Development," and also in "The Dean's Lecture" at the University of Nebraska.

Some other examples of courses in which ethics is treated formally, if not exhaustively, include: "Engineering Law" at the University of Arkansas; "Engineering Contracts" and "Senior Seminar" at the University of Colorado; "Senior Survey" at Ohio State University; "Professional Orientation" at Rose Polytechnic Institute. Still other schools which have reported that they treat ethics formally in course work include Massachusetts Institute of Technology, Pratt Institute, Purdue University, and the University of Texas.

Several schools, going beyond the lecture method of presentation, try to get the student involved in problem situations. At the University of Tennessee, in a senior lecture series directed by the Dean, the students are required to bring in to a discussion session a problem which raises an ethical issue. At the University of Pennsylvania, in a course on "Problems of Personal and Professional Relations," a number of subjects relating to ethics are analyzed on an informal (and often confidential) basis.

Although the data to support such a generalization are lacking, we venture to say that every instructor at one time or other introduces some aspect of ethics into his teaching. More often than not it is done on the spur of the moment and quite informally, but it is nonetheless effective.

Indeed, many professors have said that ethics is taught best in this way. What better time is there to discuss ethical codes than when a cheating

episode arises, for example? Incidentally, speaking of cheating, the West Point scandal of a few years ago was "fodder" for a very interesting paper ("Who's Cheating in Examinations," by F. T. Mavis, *Engineering News Record*, September 13, 1951) on ethics—at least I would so classify it. I commend it to you if you haven't seen it.

Most of the schools that do not teach ethics in a formal way, and many others, mentioned that ethics is one of the subjects discussed year after year in student meetings. The speaker may be a student or a faculty member, or often, an engineer from industry. One of the means used to stimulate interest in meetings of this kind has been to arrange a panel presentation including with the engineering point of view the viewpoints of other professions such as law or medicine, say.

The environment of the institution has "cropped up" in report after report as being one of the most significant factors affecting the teaching of ethics, in church-affiliated and nondenominational schools alike. A statement of objectives which includes reference to helping the student grow morally as well as intellectually may help to establish the environment in which the learning of ethics will flourish.

Actions speak louder than words, however, and thus it is that faculty behavior—that is, how the members of the faculty think and act and teach—is an all-important determinant in establishing the moral tone of a school. Three colleges, California Institute of Technology, Princeton University, and Webb Institute of Naval Architecture, have reported that their honor systems contribute immeasurably toward establishing a desirable moral climate. Many will assert that in fact there is no better indirect influence for inculcating ethical understanding than a working honor system, one believed in by staff and students alike.

This, then, in outline, summarizes what some of the colleges are doing about ethics. It is admittedly a skimpy report, but it may be sufficient to serve as a basis for our asking some pertinent questions—which, after all, is about as much as we should expect of such a study.

Let us agree that, as the 1953 Committee report recommended, it is indeed the obligation of our faculties to teach our students general and professional ethics, and to motivate them to comply with ethical standards. Can we also agree that this concern should be implemented by appropriate *specific* and *formal* measures?

If so, how shall we teach ethics? How little can we get by with? How much should we do? What and how much material in general and professional ethics should be required, that is, prescribed in a course outline? What and how much should be left to the individual teacher? . . . or to the student? How effective are the various methods of instruction?

The answers will vary with each institution, and with individuals within each institution, but by our obligation to teach ethics, we must seek them. One of the major defects in the present situation is that few if any schools have a comprehensive, planned program for teaching ethics. So much seems to be more or less just left to chance. Unless and until we are willing to face the issue squarely, there will be little change from what we are now doing.

AN EXCURSION THROUGH EXACTITUDES

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Recommended by the Mineral Engineering Division

I

It is a matter of commonplace today that the United States has need of more young engineers; and we are told that they are being turned out in good supply by the Soviet Union. The generation reflecting the first wave of the birth-rate break-through of World War Two is fast approaching college age. Were we content, in this country, to treat the production of engineers on the basis of quantity only, there would appear to be ample raw material for the operation; but when we turn to the quality of our educational product, it is a more elusive proposition. Yet the quality of our effort will leave its mark upon us; and if I had any lingering doubt as to the truth of this, the jet-plane breaking the stillness of the sky outside my study would drive it from me.

There is, among teachers of engineering today, a deeper concern for getting at some of the roots of education than has been evident in a goodly number of years. There is a stirring that is worth the notice of it, and a feel of changes that are in the making. The trend, and it is fairly definite, is beginning to take form: it revolves around the notion that engineering education can be made more "professional," and at the same time more "fundamental," by the relatively simple expedient of increasing the emphasis on mathematics and on science —at the expense of a diminishing emphasis on engineering itself. Since all branches of engineering rest—to an important degree—on applications of mathematics and science, this trend appears desirable to an appreciable and perhaps major segment of our engineering educators.

I would be as fundamental as the next man, but what seems fundamental to me may not fit in with the way he chooses to use the word. I cannot see that only one kind of fundamentalism merits recognition. If my friend tells me that mathematics and science are fundamental to engineering education as subject matters, I shall agree with him; but I maintain that mere subject matter, as such, is not the only consideration and that it may not even be the controlling one.

A balanced mental development of our students—as an objective—would seem fully as fundamental to me as a thorough indoctrination in mathematics and in science. I would agree—indeed, I would insist—that the latter merits a strong place in the engineering curriculum; but at the same time I would insist with equal vigor that the cultivation of judgment and intuition go hand in hand with continuous exercise in exact and rigorous methods of thought.

II

We say that five plus five is ten. We have five fingers on the one hand

and five on the other, hence we have ten in all—an interesting and, perchance, useful piece of information; yet for my part, I am more concerned with what I do with my hands than with whether I have ten fingers or have twelve. The astronomer can give us the hour and the minute and—if we press him—even the second that the sun will rise on New Year's Day in the year Two Thousand; yet I am more interested in what kind of a world the sun will rise on when the year Two Thousand comes, and whether any influence of mine upon it shall, in the long run, have been for better or for worse.

When we seek for something we can tie to in the shifting scene around us, some of us turn to numbers, and they bring us confidence. For, we may tell ourselves, two times two is four, and I am certain of it—it is absolutely so and always has been, and so will it always be. To tie ourselves with numbers is a fairly simple matter; but to get ourselves untied again is a more troublesome proposition.

If a man earns ten dollars on the first day and another ten the second, he will have earned himself twenty dollars in the total; but he may have the twenty dollars in his pocket after the second day, or he may have none of it. The work that he did to earn it may have been fruitful or, perhaps, quite useless; and the money that he earned may bring him blessings or, perhaps, some misery.

If my neighbor works the first year putting himself up a house, and the second taking it down again, his two years' work add up to nothing—save for the exercise and the experience he gains and, perhaps, the enjoyment of it. When we count with numbers, we may be right, or wrong—and we can prove it; but the right or wrong of numbers may have little to do with the things that count in life.

I would be a mathematician, because we need exact relationships; and I would seek for new ways to relate things to each other. But because I understood methods of computation in certain complex matters, I would not mistake myself that the whole world could be figured out. I could reckon the exact number of green leaves on my maple tree, if you forced me to it; but I could not calculate their beauty in the fall.

If my friend tells me that there are methods of relating all things—such as even the slightest topographical variation in Afghanistan to the price of beans in the Boston market—I shall have to concede the possibility of his thesis. But I doubt that I shall ever discover the theorem that relates the two of them or, for that matter, take the trouble to study it out should someone write a learned paper on it.

As far as I am concerned, there is a relation—however remote—between all things in existence; but comparatively few of these relationships are, or will ever find themselves to be, subject to exactitudes. The remainder must be dealt with otherwise; and I for one, would not be afraid to trust my judgment in the matter of the Boston beans—which tells me that the effect of even the tallest mountain in Afghanistan is a great deal less than I would want to measure.

I would be a scientist, because we need to systematize knowledge as we seek the truth, and I would strive to pass the limits of the known; but I would not let the impact of things that can be systematized prevent me from remembering that there are some things only partly systematized—and

some, perhaps, never to be systematized at all. I have a fairly good filing system in the corner of my study, and a box in the county bank; but some of the things that mean the most to me are scattered in other places.

If my friend insists that the systems men have found in things are ever growing larger, I will agree with him; but if he suggests that in time they will come to include most—and perhaps all—of everything, it will have my question. A complete system of all things would, presumably, let us foretell the future as readily as we can recite the past. I have enough trouble trying to live down the mistakes I have made in the past without having to live up to those I will make in the future. I doubt, however, that I have need for much concern on this score, since total system—if ever deduced—is not very likely to be figured out during my lifetime.

There are times, of course, when I wish I could predict the future. I might be planning an excursion, let us say, for the week end after next; and having set the date, wish I could settle also for the weather. Perchance there will come a time when weather at that distance can be predicted with great certainty; but we have not caught up with it as yet, so I must judge the matter.

My friend will tell me I should be statistical, and will produce records to support him in his view; for, he will say, if—on that day—only ten in the last fifty years recorded rainfall, then only one chance in the five points to it now. If this meant that I would get but one-fifth wet, I would not mind it; but if the rain should drench the rest of me as well, it is another matter. I would take little comfort, if I were most uncomfortably wet, in the thought that I was still statistically dry.

I once knew a man who lived to be a hundred and four years old who, on his hundredth birthday, attributed his longevity to the fact that he had never died. He had six living children, twenty-two grandchildren, and—at the time of his death—some thirty or more great-grandchildren. Once a year, as many of his progeny as could be inveigled into it, together with their wives and husbands, convened for a family reunion—which I, despite my better judgment, attended on occasion.

I never had the least idea who many of the people were; but there were some among the ladies of the second generation who seemed to know the origin of every distant cousin and the ownership of every boisterous youngster. There are doubtless those who will say that I should have concerned myself with this system of relationships. I have a great respect for the exact relationship of things, but I have an equally great respect for judgment and in this instance I placed the greater value on my judgment, since—had I followed it—I should never have attended in the first place.

If my friend claims most of virtue for the exact processes of thought, I shall debate him; for exact thinking—however valuable—can, by itself, be used only when things are wholly systematized. If I claim most of virtue for judgment, he should just as surely debate me; for judgment—however valuable—needs the support of the exact mental processes. I have mixed prize seed with poor soil, and poor seed with rich soil, and have raised something of a crop each time; but the crop has been best when both the seed and the soil were good. I would say that he who depends on exact

thinking only is, so to speak, only half a man; that he who depends on judgment only is, so to speak, only half a man; and that to be whole—in this sense—an engineer must be able to integrate the two. The absence of either is a serious detriment; and any reasonable balance between the two is a blessing to be sought and cherished.

III

My friend, when young, lived in a rural town; and though he wandered some, he kept familiar landmarks in his view. One day he learned of maps, and he secured one; and with the system of the township thus spread out before him, he could then find his way where he had never gone before.

When he had mastered all his first map taught him, there were other maps that showed the woods beyond. In time he had traversed all that had been plotted, and had learned the way of making maps as well; he could then strike out into the virgin wilderness, charting his way behind him as he travelled, and sighting new vistas as he mounted each fresh peak.

I was a native of the same small town; and for a time I roamed the hillsides with my friend. But as the years slipped by, our pathways grew divergent—his to the mapping of new country as he explored the unknown reaches beyond the hills, and mine to the building of new structures as I explored the needs and wishes of my fellow men. Others had built well before me— but with the maps my friend made, I could build better still. They showed me many things that I made use of; but I still had need of things that were not shown.

I had a need of knowing if Miller's River would ever crest my bridge, but it was not on the map; I looked for whether the price of steel in Pittsburgh would go up or down, but it was likewise missing; I sought to find out whether next fall's hurricane would strike us from the south, but could not ferret out the answer. I did not blame my friend for this, for it was through no fault of his. There are some things—like Farmer Brown's cow —that neither stay put in one place for a long time, nor can be counted on to follow a parabola.

The things my friend discovers are, in a sense, already in existence; but what I build does not exist, as such, until I fashion it. He takes things apart, so to speak, as he gains an understanding of things not understood before; but I put things together as I build a structure that never stood before. He meets his challenge as he explores outward from the charted known; but I meet mine as I build upward from the partially charted and the partially unknown.

The stresses in my bridge do not know whether or not the town meeting will vote the money to let the bridge be built; I can start in with a single site, and a definite notion of what must travel over it, and come out with a dozen different bridges— and any one of them will take the load; and unless I am a very poor builder indeed, and my span comes tumbling down about me, I have no certain way of knowing whether the bridge I build is good or bad.

For my part, I doubt that a great study of what is known about the related and the exact, is the best preparation for great skill in dealing with the unrelated and the inexact. I would say that while a man is engaged in serious wrestling with the first, there is less likelihood that he will grapple with the other and get

the practice of it. It may even be that if he simmers in relationships and exactitudes for so long a time that exact thinking becomes his second nature, he will have lost something of his first nature—which was to depend on intuition and on such judgment as he had.

To master the exact part of something, and to do a good job with the total, are two quite different things. They are not necessarily mutually exclusive, but if I were to judge by some of the people I know, I would not be so certain of it. The lady who lives down the street from me knows more about calories and vitamins than anyone else in the county; but when I want a good meal I, for one, shall visit somewhere else.

IV

I would compare science to a map, only in the sense that both deal with things that form a system; and I would include mathematics into the bargain only because—like the map—it deals with exact relationships. My friend, I know, will not agree with me, but I hold to the view that the study of mathematics and science by engineers is potentially a less favorable climate for the cultivation of judgment and intuition than is the study of engineering itself.

Even the most elementary problem in engineering is—if properly presented—a challenge to intuition, to imagination, and to judgment, as well as to the more exact and rigorous mental processes; were this not so—were the problem completely defined and admitting of but a single so-called "correct" solution—it would not, in the true sense, be engineering.

The engineer must have a firm base of systematized knowledge, but in professional practice such knowledge is only a background for most of the situations he will encounter; he must operate in areas that are in part above and beyond the well-documented but relatively limited areas of systematized knowledge. Perhaps the principle function of the truly professional man is to harmonize and relate the conflicting forces and tendencies that arise because of the very fact that the total systematizing of knowledge is an impossibility.

Such a process of harmonizing and relating is not a science, but an art in the highest sense; and if—in the name of professionalism—science be elevated to a point where the respectability of the art of engineering is substantially lost, the very essence of professionalism may likewise be lost in the process.

It should be recognized that as soon as any area of knowledge becomes substantially systematized, it thereby becomes essentially sub-professional in character—however complex it may be, and however important it may be as a partial base for professional operation. If a thing is systematized, it can be mechanized—or, if it should not be economical to build a machine, it can be highly organized so as to become capable of routine manipulation. Engineering, stripped of the art, can degenerate into scientific vocationalism.

There would also seem to be advantage, although I shall refrain from expanding on it here, in teaching science and engineering in parallel with each other—rather than following the time-honored custom of completing the first before the second is begun. If they were assimilated simultaneously, exact thinking and judgment could develop at the same time and there could be full interplay between

the two; there could be—as my friend would say—a "feed-back" from each one to the other. I am more interested in the corequisites of mental development than in the prerequisites of subject matter.

(See also for a further development of the so-called "vertical" system: "Limitations of Logic in Engineering Education," *The Technology Review*, 57:5 (March, 1955), M.I.T.)

Too much preparation can stifle even the genius or, perhaps, especially the genius. I once knew a country spinster who told me about all the things she had done to get ready for her parents' golden wedding anniversary. There could be no doubt that she had gone about it systematically, and with a prodigious amount of effort. She had cleaned the farmhouse from the cellar to the attic—had baked a pantry full of pies and cakes—and she had carried through a hundred and one other tasks with skill and loving care. "Why!" she exclaimed, as she came to the end of her recital, "We even had the cheeses all made, and then my father up and died!"

The pendulum of engineering education which, some years ago, had doubtless swung too far in the direction of engineering practice, seems now in danger of too much rebound into the realm of science. As far as I am concerned, I shall use my influence to minimize the overswing. We would not think for a moment of dropping the human values from engineering education; and we should guard the judgment values with an equal zeal.

DECEASED MEMBERS 1956-1957

Francis J. Adams
R. L. Albrook
John Anderson
Leslie H. Bacher
W. S. Beattie
Jules Bebie
William C. Bergman
Harold L. Black
Patrick F. Brandenburg
George W. Case
A. R. Cullimore
V. Daughterty
William C. Davis
C. R. Dooley
Richard A. Fayram
Howard M. Gifft
Parker M. Green
Joseph B. Hershman
A. S. Hill
Milton Hindle
Jack J. Hinman
Emory Kemler
Raymond E. Kirk
Herman B. Leonard
G. H. MacCullough
Malcolm S. McIlray
Fred O. McMillan
Perry E. Moose
John C. Parker
W. B. Plank
W. J. Schlick
M. I. Signer
R. K. Slaymaker
George W. Stewart
C. F. Strobel
Roscoe H. Suttie
Ray S. Swinton
Donald W. Taylor
Arthur W. Walker
Albert E. White
G. Edwin White
Harold A. Williamson
Arthur L. Williston
Walter J. Wohlemberg
Baldwin M. Woods

METALLURGICAL ENGINEERING AND ATOMIC ENERGY

R. CARSON DALZELL

Chief, Engineering Development Branch, Division of Reactor Development
U. S. Atomic Energy Commission, Washington 25, D. C.

Presented before the evening conference of the Mineral Industries Division, June 18, 1957; recommended for publication by the Division.

"I want to tell you tonight about the role that metallurgy and ceramics are playing in atomic energy and about some of the educational programs that the AEC has initiated to assist engineers in obtaining the type of education and training necessary for today's complex problems."

Complex problems are not new to metallurgy. At the beginning of World War II, for instance, metallurgy faced challenges from an expanding aircraft industry. New materials were needed to meet more exacting and rigid requirements for high speed airscrews, new types and sizes of engines, landing gears, and highly stressed airframe structural members. These problems were successfully solved by the introduction of new alloys of aluminum, of iron, and of other metals.

Today the metallurgical industry is meeting a fresh challenge brought about by an expanding nuclear energy industry. While many problems still require solution, we can point to significant accomplishments. Uranium-aluminum and uranium-zirconium alloys are commonplace in the atomic energy industry, and cermets have begun to play an important role.

A few years ago, metallurgists and ceramists were concerned only with such properties as melting point, tensile strength, yield strength, hardness, elasticity, density, boiling point, transition temperatures, thermal expansion, specific heat, heat of fusion, and thermal conductivity. The environments were pretty well understood.

Nuclear energy applications introduced new factors, some fundamental and others affecting only their own nature and that of their environments. Solid state physics and physical metallurgy acquired new importance. Enormous quantities of new information had to be secured and evaluated for the old alloys.

In addition, new metals and alloys had to be produced. In the recent past, few metallurgical engineers had heard of, much less had contact with, metals such as hafnium, zirconium, thorium, niobium, uraninum, and gadolinium. The modern metallurgical engineer must know the characteristics of these and many other materials if he is associated with any phase of nuclear energy technology.

Metals

To play its role effectively, a metal must have been selected for certain characteristics. In addition to mechanical, physical, and corrosion resistance properties, metals employed in the atomic energy field must pos-

sess suitable nuclear properties. These are not associated with valence electrons, as are chemical properties, but with the nucleus itself.

Let me briefly explain the significance of one of the most important nuclear properties of materials, namely, the thermal neutron cross-section. This nuclear property determines the extent to which a material interacts with a neutron. Knowledge of this property is important because reactor construction materials are immersed in a neutron environment.

Whenever a nuclear reaction occurs, it is accompanied by the disappearance of neutrons from the chain reaction system. In terms of neutron economy, therefore, a material with strong neutron absorbing properties tends to put the neutron balance sheet in the red.

After considerable research, metallurgists and physicists determined that zirconium, free from hafnium, has a low cross-section for thermal neutron absorption. This property, together with good mechanical strength at room and elevated temperatures and excellent corrosion resistance, makes zirconium alloy technically one of the most suitable materials for nuclear fuel assemblies and structural parts of nuclear reactors.

For example, fuel elements containing fissionable materials are clad with zirconium to protect them from corrosion when they are immersed in water, heavy water, or other liquids. In a reactor that employs high temperature water or steam as the heat exchange medium, the rates of heat transfer per unit area are very high. Indeed, they are tremendous when contrasted with conventional fuel power plant practice.

The protective zirconium sheath or cladding is on the front line in this situation. Inside the zirconium sheath is the hot fuel element; outside, water or steam. If the reactor is to be successful, the effects of localized overheating, thermal stress, fatigue and corrosion must all be withstood. Zirconium meets such demands well. Aluminum is satisfactory when requirements are not too severe, but, as a rule, in power reactors, the added cost of zirconium construction is well worth while to gain the higher temperatures it permits.

When considering a material for use in a nuclear reactor, one must also take into account the effect of highly energetic neutrons and fission fragments on the crystal structure. The fission process is accompanied by emission of high energy neutrons and highly energetic heavy fission fragments. These neutrons and fragments have the ability to displace atoms in the lattice of materials and consequently to change the mechanical properties of the material. We call this irradiation damage. The effect is like a combination of "cold work" and alloy-hardening of metals. Irradiation damage can be *partly* removed by annealing.

Ceramics

Although I have used metals for illustration, the effects are equally apparent in ceramics.

A few years ago, it was difficult to find a ceramics engineer in industry. Today, however, so much accent is being put on ceramics for high temperature operation in aeronautics and astronautics, and in operation of high temperature nuclear reactors, that research and development activity in the ceramics industry is experiencing a revival. I can give a good indica-

tion of the healthy progressive attitude which is developing. We want a fuel element, low in cost, to operate at 2500° to 3000° F.—almost surely a ceramic.

A year or so ago, the AEC would definitely have had to give complete research and development support. Today, we are simply letting our need be known and suggesting that our Chicago Operations Office would be glad to hear any propositions. Because of the large potential demand, it is likely that the AEC will have to supply little if any money for this research and development.

Obviously, the nuclear industry is not only creating a need for broader knowledge on the part of metallurgists and ceramists, but also a need for more men trained in these fields. The AEC recognizes this and is conducting a many-pointed program to assist in meeting the need.

Educational Facilities

Perhaps the most unique school that the AEC is conducting is the International School of Nuclear Science and Engineering at Argonne National Laboratory. Here both foreign and domestic students take an intensive course covering most of the disciplines involved in the development of nuclear energy.

These "Reactor Engineers," as they are called, learn how to handle many special materials and perform experiments under the guidance of ANL specialists. In the nuclear metallurgy courses at the Argonne School, the students perform laboratory experiments in the following areas of metallurgical engineering:

1. Powder metallury
2. Extrusion of Aluminum-uranium alloys
3. Liquid metal corrosion
4. Ceramic fuels
5. Radiation damage
6. Welding and brazing fuel elements
7. Uranium-zirconium alloys
8. Uranium-chromium alloys
9. Corrosion of cladding materials
10. Heat-treating of uranium alloys
11. Machining of uranium
12. Melting, fabrication, and heat-treatment of thorium

This Argonne School is only one of several educational activities the AEC is sponsoring at the national laboratories. But first I wish to tell you about the programs for assisting *universities and colleges* in the training of engineers.

AEC Assistance

In September, 1956, the Atomic Energy Commission announced a grant program for financial assistance in nuclear energy technology training. This program enables the AEC to award grants for equipment up to a maximum of $350,000 per educational institution and to loan special materials peculiar to nuclear energy technology. It is designed primarily to assist *accredited* engineering schools by awarding grants for equipment needed to offer courses at the graduate level in nuclear engineering.

Provisions have been made, however, to award grants to both accredited and non-accredited institutions for the acquisition of equipment on a limited basis for the development of basic nuclear technology courses at the *undergraduate* level. The grants are made under the conditions that the equipment and material will be used solely for educational purposes. The grant program is ex-

pected to be in effect for several years. After this time, it is felt that courses necessary for professional work will be firmly established in the universities and colleges.

I like to view this program as a boost that helps the educational institution over a financial hump that might have taken 20 to 30 years or more to get over without AEC assistance. To indicate the magnitude of the capital investment that a university or college would have to make to establish courses in nuclear energy technology—in some instances at the expense of salaries to the teaching staff—let us consider the categories of equipment for which grants can be made under this program.

The list includes nuclear reactors, radiation detection and measurement equipment, heat transfer apparatus, apparatus for instruction in corrosion and erosion, chemical equipment for laboratory instruction in reprocessing and decontaminating irradiated fuel elements, nuclear reactor simulators, and, of course, equipment for laboratory instruction and fabrication of metals and alloys which are directly related to nuclear energy technology.

Since some of the categories of equipment are of prime interest to this audience, I will summarize the present status of this program insofar as equipment for training in metallurgy is concerned.

To date, the AEC has awarded grants to 34 colleges and universities totaling $3.36 million. Of this total figure, approximately $610,000 was divided among 12 colleges and universities for ceramics and metallurgical laboratory instruction equipment for use in extensive programs in these fields. In addition, several of the remaining 22 universities received grants of various amounts for metallurgical laboratory and ceramics laboratory equipment which were proposed by the mechanical engineering or chemical engineering departments. I regard this as an interesting proportion —about 20%. On the average, about 35% to 40% of the bill for developing and building a new reactor is for materials work of one sort or another.

The types of equipment for which grants have been made include heat treatment furnaces, vacuum furnaces, muffle furnaces, salt-bath furnaces, induction furnaces, heat treatment ovens, rolling mills, x-ray diffraction units, controlled atmosphere furnaces, swagers, sonic testers, abrasive cut-off wheels, powder metallurgy dies, dilatometers, metallurgical microscopes, metallographs and special equipment, such as slave manipulators and glove boxes, peculiar to the techniques of handling radioactive materials.

Permit me to read you a *list of some of the experiments and demonstrations* that will be performed with equipment under these grants.

1. Preparation of Metallic Uranium and Thorium from Tetrafluorides
2. Vacuum Melting and Casting of Unalloyed Uranium
3. Consumable Electrode Arc-Melting of Unalloyed Thorium and Zirconium
4. Vacuum Melting, Alloying and Casting of Aluminum-Uranium and Uranium-Zirconium Alloys
5. Extrusion of an Aluminum-Uranium Alloy

6. Fabrication and Examination of Unalloyed Uranium, Thorium, and Zirconium by Forging, Swaging, and Rolling
7. Fabrication and Examination of Aluminum-Clad, Aluminum Alloy Fuel Element by Rolling
8. Fabrication and Examination of Zircaloy-2 Clad, Uranium-Zirconium Alloy Fuel Element by Rolling
9. Thermal Treatment and Examination of Unalloyed Uranium and Uranium-Zirconium Alloy
10. Metallography of Uranium and Uranium-Aluminum Alloy
11. Metallography of Zirconium and Zirconium-Uranium Alloy
12. Fabrication, Testing, and Metallography of Fuel Elements
13. Determination of Relative Resistance to Aqueous Corrosion of Unalloyed Uranium, Thorium, and Zirconium, Aluminum-Clad Aluminum-Uranium and Zircaloy-2 Clad Uranium-Zirconium Fuel Element
14. Powder Metallurgy of Cermets
15. Corrosion of Reactor Materials

Summer Institutes

Another important training program in which the AEC is co-sponsor is the Summer Institutes at five AEC laboratories. The one of prime interest to this audience is the Advanced Nuclear Metallurgy Institute at the AEC's Ames Laboratory, in joint sponsorship with your society. This program is designed to give university faculty special training in the latest technology associated with the application, fabrication, and handling of special nuclear materials currently being used in the atomic energy program.

In conclusion, I believe we can agree that the education and training programs I have mentioned should help to eliminate the current shortage of qualified engineers in the metallurgical industry.

WOODROW WILSON FELLOWSHIP PROGRAM

An intensive, nationwide effort to combat the mounting shortage of college teachers has been inaugurated by The Ford Foundation, which has granted a $25 million appropriation for a large-scale extension and development of the National Woodrow Wilson Fellowship Program. It will support a broad program to attract able college students to the academic profession, and will provide 1,000 graduate fellowships per year to potential college teachers for the next five years. Individual awards, which will be applied to tuition and living expenses for the first year of graduate study, are expected to average $2,200 and will require approximately $11 million of the total appropriation. Another $10 million will go to the universities for aid to graduate students beyond the first year.

AEC EDUCATIONAL ASSISTANCE TO ENGINEERING COLLEGES

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Director, Division of Reactor Development
U. S. Atomic Energy Commission
Washington 25, D. C.

You are all well aware of the serious shortage of scientific and technical personnel. We must attract more young men and women into science and engineering and enhance their educational opportunities if this country is to maintain its expanding technological character and its technical leadership in the world. Many programs are being planned and undertaken, individually and collectively, by Government agencies, industrial firms, and educational institutions in order to alleviate the shortage of technical manpower.

The Atomic Energy Commission is keenly aware of this need. Chairman Lewis L. Strauss, Commissioner Willard F. Libby, Admiral H. G. Rickover, and other Commission representatives have made numerous appeals to industrial, academic, government, and philanthropic groups to awaken them to this national problem and to promote bold, new programs to solve it. Our program of educational assistance to colleges of engineering is a direct outgrowth of the Commission's interest and concern.

AEC Responsibilities

From the beginning, the Commission has recognized that its activities in the field of education must be supplementary and subordinate to those of our schools, colleges, and universities. We are well aware of the sound American tradition that education must be independent of governmental control. The educational program of the Commission during the past decade has accordingly followed the principle of "help without hindrance."

Further, the AEC has recognized its own limitations in taking direct steps to help solve these problems. We have not felt that we had a charter to seek answers for difficulties in areas not of special and direct concern to the AEC's own programs.

We recognize the breadth of the problem and are supporting the efforts of others in these broader fields but have had to confine our own programs to those which are pertinent and critical to our own fields of endeavor. In addition, it seems clear that with the amount and kind of direct assistance which the AEC could reasonably be expected to provide, we would accomplish more by directing our efforts into fields of special interest to us than by dissipating energy over the whole spectrum.

It is perhaps worth remarking also that the AEC has fared quite well in the competition for scientists and engineers not only in quantity but also in quality. This is due, no doubt, in part to the glamor attached to this new field but also, I am sure, to the many challenging opportunities for new, unusual, and exacting work. However, we recognize that this bene-

ficial situation will not persist for a long period and that this does not diminish our obligation to the entire scientific and engineering community to carry our share of the burden.

ORSORT and ORINS

Let me tell you a little about how our program has evolved. Soon after the Commission was established in 1947, it became evident that there was an urgent need for advanced training in reactor technology. At that time, however, nearly all of the technology and much of the basic scientific data were classified information. Accordingly, the Oak Ridge School of Reactor Technology (ORSORT) was established in March 1950 as a classified training institution.

During the seven years ORSORT has been in existence, it has performed an essential service in training individuals from industry and government in the specialized field of reactor technology. Many ORSORT graduates now occupy professorial positions on your engineering faculties as well as important posts in industry.

In addition, the last two years have seen a rapid declassification of nuclear information. Except for certain military reactor applications, the field of reactor technology is now completely open. This result, coupled with the recent increase in nuclear curricula in our colleges and universities, has led to shifting the ORSORT program more and more toward advanced training.

A second activity at Oak Ridge is the Oak Ridge Institute of Nuclear Studies (ORINS), an association of 34 southern colleges under Commission contract. It provides experimental medical and radiological residencies and training in the safe and efficient use of radioisotopes.

Since its formation in 1948, ORINS has instructed about 2500 scientists from every State, from Puerto Rico, Hawaii, and the District of Columbia, and from 37 other countries. Four-week courses in basic techniques are offered approximately six times each year. Under its medical reseach program, ORINS offers one-year post-residencies in radiology and experimental medicine and three summer residencies for medical school staff.

Faculty Training

In the development of atomic energy curricula by colleges and universities, one of the most serious problems has been the shortage of faculty with experience in nuclear energy fields. To give such training, during the summer of 1956 two institutes of two months each were conducted, one at Argonne National Laboratory and one at Brookhaven National Laboratory on Long Island.

This program was undertaken by the Commission in cooperation with the American Society for Engineering Education and the National Science Foundation, and provided material for engineering faculty members to use in teaching nuclear energy technology. Sixty faculty members attended the institute at Argonne, and thirty at the Brookhaven Institute.

To insure a continuing and expanding program, this summer we have added advanced courses in reactor physics at ORNL, in metallurgy at the Ames (Iowa) Laboratory, and in chemical separations at Hanford. A specialized course for faculty interested in the Argonaut training reactor has been conducted at Argonne.

In addition, a proposal is now being considered to expand the faculty training program by establishing a number of summer research projects at selected universities or at AEC sites, where teams of college faculty can be assembled to learn by working on problems of special interest to the Commission. During the summer of 1956, more than 300 college faculty members were employed at Commission facilities. During the regular academic year, faculty members have participated in research programs at AEC laboratories on leaves of absence from their colleges and universities.

I should like to observe that our National Laboratories provide unequalled opportunities for research in many fields of science and engineering. These include the use of equipment which could not be duplicated by any university.

It is our hope that we can find additional ways of making these facilities available for academic purposes, including graduate research. We have thought of establishing university-operated "engineering stations" or something of that nature, perhaps similar to the M.I.T. School of Chemical Engineering Practice Stations, but covering a broader field. We have not completed our thinking on this matter, however, and would welcome any suggestions with respect to such a program.

The International School of Nuclear Science and Engineering (ISNSE) at Argonne National Laboratory was established in 1955 to make available to our friends abroad adequate graduate-level education in nuclear science and engineering as a part of the President's "Atoms-for-Peace" program.

This school accepts foreign nationals as well as students sponsored by American industry. In fact, it was felt highly desirable to have both types of students, not only to assist in establishing friendly working relations between individuals but also to insure that the quality of the training was maintained at a level acceptable to and useful for Americans as well as people from abroad. Of the 287 students to date, 211 have been from 28 foreign countries and 76 from the United States.

Many countries would like to send more students to this school. Pennsylvania State University and North Carolina State College, both of which have research reactors, now participate in the program by providing the first semester of study, after which a second, advanced semester, is provided at Argonne. This cooperative plan has made it possible to accept up to 120 students each year, as compared with 60 per year previously.

AEC fellowships in Nuclear Energy Technology (117 awarded for 1957–58), in Radiological Physics (69 for 1956–57) and in Industrial Medicine (7 in 1956–57) are attracting talented scientists, engineers, and physicians to these fields in which the need is especially acute. Funds for research in physical science are also provided through research contracts with colleges and universities. There are approximately 300 such contracts with about 100 institutions, providing part-time employment for an estimated 1200 graduate students who are thereby enabled to obtain experience in advanced research work.

College Facilities

The Commission firmly believes that adequate experimental and laboratory facilities are essential for any educa-

tional program in the fields of nuclear science and engineering. We do not consider that every university needs to have a reactor or, indeed, any particular type of equipment.

Access to reactors and other highly specialized equipment is certainly desirable for many purposes but can be accomplished in different ways. However, the integration of appropriate laboratory experiences into any such programs is important, and the Commission has undertaken to make grants to provide equipment for such purposes.

The Commission assists educational institutions in acquiring training reactors, teaching aids, demonstration apparatus, laboratory equipment, and certain nuclear materials to be used primarily for educational and training purposes in nuclear technology courses. Under this program the AEC will consider the loan of source, special nuclear, and by-product materials, as well as graphite, heavy water, zirconium, hafnium, rare earths, neutron sources, and other supplies peculiar to nuclear energy technology. To date, 16 such loans have been made to universities and colleges.

Grants for Equipment

Also, under this program, the Commission makes direct financial grants for the procurement of equipment. More than 60 proposals for grants have been received since the Commission's assistance program was announced last September. Thus far 34 educational institutions have been awarded such grants for a total of $3.3 million.

Included have been funds to purchase 10 reactors for training purposes. Grants for the purchase or construction of nuclear reactors for engineering education are made only to Colleges of Engineering which have courses of study in nuclear energy technology at the graduate level and are accredited by the Engineers' Council for Professional Development in one or more of the usual engineering fields.

Student Supply

The Commission is also making efforts at pre-college levels to stimulate interest in science and engineering careers. In collaboration with the National Science Foundation, we initiated last year a traveling science teachers program.

After a summer of training at Oak Ridge, a selected group of high school teachers spent nine months visiting schools throughout the country as disciples of nuclear science. Last February over 4400 high school students, most of them enrolled in science courses and accompanied by their teachers, visited major AEC laboratories and production facilities.

Finally, some 10,000 sets of published material in the nuclear field have been distributed to elementary and high school students. These information kits provide answers to the more common questions on careers in nuclear science and technology and on nuclear power. We hope they will help interest high school students in such careers.

There is considerable evidence that the shortage of engineering manpower is beginning to right itself. This is probably due largely to enhanced economic opportunity in the field.

I am sure that the efforts that educational groups, government, and industry have made have also contrib-

uted to these results. Let us examine some of the evidence. I think you will find it encouraging.

The number of engineering degrees granted in 1955–56 increased over the preceding year, while the number of all college degrees decreased. At the bachelor's level the data showed 26,306 engineering degrees, an increase of 16.5%, while total bachelor's degrees decreased 14%.

There were 4724 master's and predoctoral degrees in engineering, an increase of 5.4%, while all degrees at this level were down 1.3%. For doctor's degrees, the tally showed 610 in engineering, an increase of 1.8% as against a 6.4% decrease in all fields.

Narrowing our focus for a minute to the atomic energy field, a survey of course offerings in nuclear science and engineering has been conducted among 150 accredited engineering colleges by the American Institute of Chemical Engineering. It reveals that during the 1956 academic year 73 colleges offered a total of 269 courses, an increase of nearly 100% over the preceding year both in the number of colleges and in the number of courses. In nineteen of the colleges there were five or more courses offered in these fields of nuclear study.

From all these data it is clear that there is a trend in the needed direction toward an increased flow of manpower into the engineering field. I have no measure of the quality of these students but have no reason to believe that it is not being maintained.

Faculty Use

I would like to turn now from the subject of students to the utilization of faculty. In considering how best to use faculty members in the field of nuclear science and engineering, I would like to quote my former professor at M.I.T., Dr. Walter G. Whitman:

> Although there may be an unprecedented demand for graduates in this field, the real need is for well-educated engineers to apply the fundamentals and tools of science to nuclear developments. Many students will prefer the environment of one of the established disciplines of science and engineering, and the first task of each university should be to see that these students have the opportunity to obtain some insight into nuclear technology without necessarily taking formal courses in nuclear engineering. This may be done by encouraging faculty members to gain experience in nuclear applications so that they may bring background, experience, and interest in the field of atomic energy to the student through the courses they teach.

I would go even further. I do not believe that there is any more need for a new engineering field called "nuclear engineering" than there was many years ago for a new area called "chemical engineering." I say this despite the fact that at least at one time I considered myself to be a chemical engineer.

You may argue that history has demonstrated the need in the case of chemical engineering. The same history also shows, however, that the older fields of engineering were not willing or able to adapt themselves to new concepts and requirements and that it was thus necessary for a new field to be created which otherwise might never have been needed.

If the mechanical engineers of forty years ago had been willing to think about other fluids than air, water, and steam; if the materials people of that time had been able to expand their

horizons past steel and wool; if their chemistry and physics colleagues had been willing to consider practical thermodynamics, heat and mass transfer processes, kinetics; and if there had been a mechanism for reorienting the educational system in terms of the then new requirements, I do not believe that there would have ever arisen a separate field of chemical engineering.

Curricular Organization

The situation in engineering today is perhaps even more serious than it was 40 years ago because we are less able to afford the luxury of starting a new field. It seems to me that engineering has already been proliferated and fragmented to an untenable degree. Before we consider establishing a new field of "nuclear engineering," I think we should ask, what do engineers do in the atomic energy program as it is now constituted?

The answer is that most of them are engaged in their usual type of engineering work. However, there is a substantial and growing number of engineers engaged in research, development, design, and operation of reactors and specialized facilities required in reactor systems. These are the people who might be called the "nuclear engineers" assuming there is any validity to or necessity for such a designation.

I should, however, admit at this point that there is a strong argument for curricula in "nuclear engineering" which rests largely on its "sales appeal," or "consumer motivation." This is important to many students who like to feel that they are becoming something more specific than just an engineer, regardless of the validity of this urge.

It is perhaps more important to the engineering departments and colleges who need to utilize this sales appeal to secure the additional faculty, buildings, and facilities they so badly need to carry on this engineering program. Though we may regret the circumstances which necessitate such an approach, I fear that we cannot eliminate the importance of this factor.

I think what is needed more than anything else to build strong curricula in nuclear technology (or curricula furnishing a sound basis for later work in engineering in the nuclear field), is an active interest on the part of individual members of your engineering faculties. If you have only two or three scientists or engineers experienced in this field supported by interested professors of chemistry, physics, biology, metallurgy, economics, civil engineering, mechanical engineering, electrical engineering, and architectural engineering, you have the necessary ingredients for a completely integrated course of study in nuclear technology.

No school at the present time has this breadth of coverage. A number, however, have this as their objective, and are starting out with specialization in limited areas related to the specific interests of their faculty members. The AEC assistance program is intended to help in establishing such curricula.

Problems and Solutions

In carrying out our educational program we have encountered some problems. I would like to tell you briefly what we have done to solve them. In selecting colleges and universities to

participate with ORSORT and the Argonne International School, a number of specific criteria had to be satisfied aside from competence.

First, we needed schools that could offer course work that could be integrated with the programs at ORSORT and Argonne. Secondly, we preferred schools that were operating on the quarter system in order to meet our ORSORT time schedules. Lastly, we required fairly wide geographical distribution, especially for the ORSORT program.

Over forty colleges and unversities submitted proposals to participate in the ORSORT program. Many other schools were basically qualified but did not submit proposals for one reason or another. In selecting the six participating institutions we certainly did not intend to imply that other schools were not also fully qualified.

In the number we could use, however, we are limited to only six for ORSORT and two for the International School. In selecting the participating colleges we were certainly not singling out these educational institutions for any special recognition. We made our selections on the basis of specific short-range requirements.

Eventually these cooperating colleges will develop their own course of study in nuclear science and engineering. We hope that the experience gained in these cooperative programs will be helpful not only to them but to all other institutions which are planning courses in this field.

As I stated earlier, during the first six months of the AEC program of Financial Grants to Schools and Universities, grants totaling $3,346,700 were made to 34 educational institutions. Depending on the availability of funds, grants will continue to be made throughout the coming year.

A program of such magnitude, however, cannot be established and operated smoothly without some growing pains. Some applicants have complained about a number of the requirements we have established as prerequisites to obtaining assistance. In administering these Federal funds it seemed advisable to impose certain limitations and requirements in order to prevent abuse.

For example, we have established a criterion that engineering schools must be accredited by the Engineers' Council for Professional Development (ECPD) in at least one of the recognized fields of engineering before major assistance can be given. This pre-requisite does not mean that a non-accredited school is undeserving of support. Rather, it is a mechanism whereby the Commission can avoid being placed in a position of making accreditation judgments itself since clearly the Commission is not qualified to act in this area.

In preparing a proposal for assistance, we ask the schools to describe the experiments that will be carried out with the equipment requested. To some, this has appeared to be an imposition. Unfortunately, the Commission's staff is not personally acquainted with all the faculty of our engineering schools, nor are our available funds unlimited.

We must, therefore, have data on which to judge the merits of each proposal. We are convinced that those who consider their wants carefully and have definite plans for the use of the equipment will present better programs than those who do not.

To Close

In summary, I would say that the Atomic Energy Commission is concerned about the shortage of scientific and engineering talent and is actively engaged, with the help of your Society and other educational groups, in trying to help alleviate this shortage. Recent information indicates that some favorable results have been achieved, but we still have a long way to go before the need is fully met.

In providing assistance to educational institutions, the Commission has encountered some problems. We are aware of these problems and are trying to solve them in a manner which we fell is in keeping with our democratic tradition. We hope we can continue to enjoy your support in this effort, and that you will feel free to give us your comments and suggestions as they arise.

EJC THIRD GENERAL ASSEMBLY PROCEEDINGS

The *Proceedings* of the Engineers Joint Council Third General Assembly, held January 17–18, 1957, are now available. The report includes the papers presented and the discussions of three panels: The Problems of the Engineer in Government Service, The Economic Status of the Engineer, and The Impact of the Engineer in International Relations. It also contains the three major addresses presented during the meeting. The *Proceedings*, Report Number 103, can be obtained for $1.00 by writing to the EJC, 29 West 39th Street, New York 18, New York.

RECENT EJC PUBLICATIONS

National Water Policy—A review of the recommendations to government and industry on conservation, development, control, and use of the nation's water resources from the engineers' point of view as issued in 1951. Entitled, "Principles of a Sound National Water Policy, A Restatement," the report is the work of a nine-man review board of top authorities. The EJC Board of Directors on April 23, 1957, approved the report as representing the water policy of the engineering profession. The price is 25 cents.

Engineering Educational Facilities—Full data on estimated capacity, planned expansion, and enrollment of the nation's engineering colleges, based upon a survey by the Manpower Commission of EJC. The report also covers accreditation by the ECPD in public, regional, and private classifications. It is also available at 25 cents.

Voice of Engineer—250,000 copies of the pamphlet entitled "The Voice of the Engineer," describing the make-up and activities of the EJC, are now being distributed free by EJC member societies.

THE APPLICATION OF PHYSICS TO HIGH SPEED FLIGHT

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Presented at a Conference of the Aeronautical Engineering and Physics Division, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 19, 1957.

In a short period of fifty years, aeronautical accomplishments have progressed from the first successful attempts at sustained flight to the supersonic fighters, jet bombers and transports, and rocket propelled missiles of today. There is little doubt that this rapid progress will continue and that during the next few years there will be extensive developments in the realm of flight at hypersonic speeds and at altitudes extending to the outer boundary of the stratosphere and even beyond.

The primary limit to increased flight speed has always been the propulsive power that can be obtained under given restrictions of weight and volume, but this limit is constantly being increased by new methods of propulsion. With the jet engine, for example, the speed of manned aircraft was rapidly advanced from around 400 miles per hour to supersonic speeds in level flight.

The recent development of large rocket engines has enabled the speed range to be further increased by orders of magnitude. Already the intercontinental ballistic missile and the earth satellite are approaching reality; serious consideration is being given to the possibilities of space flight beyond the gravitational field of the earth.

Physics and Flight

The increase of flight speed, however, brings technical problems far beyond the scope of traditional aeronautics. New engineering disciplines are needed to permit a rational approach to the design of vehicles for high speed flight. The fundamentals of the physical sciences provide the basis for the required disciplines, and a consideration of the applications of physics to high speed flight is therefore appropriate.

The education of aeronautical engineers merits particular attention from this point of view. Engineers must understand the fundamentals involved in the extension of aeronautical technology, and these may not be common to the aeronautical education of today.

The entire field of aeronautical engineering is made up of countless examples of applied physics. More specifically, the theories and the discoveries of classical physics are the basis for the sciences of aerodynamics, thermodynamics, heat transfer, structural analysis, stability, and control.

Thus aerodynamic theory has been assembled from the principles of Newtonian mechanics, the laws of thermodynamics, and the fundamental relationships for the physical and thermodynamic properties of gases.

Contributions of Rayleigh, Helmholtz, Boltzmann, and Gibbs, to name but a few, are integral parts of the current disciplines in aeronautical engineering, and continual recourse is had to the fields of physics or chemistry as the need for new information regarding the physical laws of nature is required.

This identification of aeronautical engineering with applied physics can be carried still further by noting that many of the basic engineering research efforts are parallel in every respect with research that might be carried out by physicists. Investigations of boundary layer behavior and turbulence phenomena are typical.

New Aeronautical Problems

The bulk of aeronautical engineering technology is not related, however, to the major advancements in physics that have been made during the last seventy-five years. The latter have resulted from attempts to determine the basic structure of matter, to describe the thermodynamic properties of finite systems in terms of the properties of the individual atoms and molecules, and to establish the fundamental laws that seem to govern physical phenomena.

The theories of statistical mechanics, quantum mechanics, relativity, and nuclear physics are representative of the fundamentals that have not yet diffused into the aeronautical technology. Some of the conventional engineering analyses may include principles of modern physics. An example is Planck's law, derived from quantum theory, which is an essential part of the laws of radiant heat transfer. Even in such a case, however, the formula rather than the principle appears in the engineering textbooks.

This separation of aeronautical engineering from the atomic and modern branches of physics has been proper, for the majority of applications with which the engineer has been concerned have required only knowledge of the properties of matter on a macroscopic scale. Simplified models of physical systems, such as the perfect gas with constant properties, have adequately represented the actual systems involved, and relativity effects have been of no consequence in the scales of time and distance to which aeronautics has up to now been accustomed.

Many of the problems of high speed flight, by contrast, alter the relationship of atomic physics and modern physics to aeronautical engineering. These problems require that full account be taken of inter-molecular distances, of the energies corresponding to various atomic and molecular configurations, and of broadened concepts for fundamental physical laws.

Specific Illustrations

A brief examination of typical phenomena encountered in high speed flight is made in the following sections. These phenomena are then related to the branches of physics that provide the necessary fundamentals. The trend in education needed by the aeronautical engineer can thus be observed.

Particular attention is focused on the problems of aerodynamics and thermodynamics. Real gas behavior at high temperatures, high altitude effects, new propulsion systems, and

relativity all demand a broader understanding of fundamentals.

Real Gas Effects

Stagnation temperature is closely approached by the air down-stream from a normal shock immediately ahead of the wing or nose of a vehicle, and by the air of near-zero relative velocity adjacent to an uncooled surface. The airflow into a subsonic combustion chamber of a ramjet engine is also at temperatures very close to stagnation value.

If the isothermal atmosphere is assumed to be a perfect gas, the stagnation temperature is found to increase from 8,200° R. at Mach number 10 to 32,000° R. at Mach number 20. At these temperatures the air no longer behaves according to the simple model with which it is represented at low speed, for the conventional perfect gas relationships assume that only molecular translation and rotation are present.

Above a Mach number of 5, the stagnation temperature is sufficiently high for molecular vibration to be significant. At a Mach number of 8, and at altitudes around 100,000 feet, the molecules of oxygen begin to dissociate and nitric oxide may be formed, while ionization, nitrogen dissociation, and electron excitation become significant at Mach numbers over 15. These various additional degrees of freedom have the effect of heat sinks that account for a fraction of the internal energy of the air.

The temperature behind a normal shock at 100,000 feet is thereby reduced from 8,200° R. to 5,600° R. at a Mach number of 10, and from 32,000° R. to 12,000° R. at Mach number 20 (1). The degree of dissociation at any Mach number, and therefore the difference between perfect gas and equilibrium temperature, is a function of the pressure level under consideration. A further consequence of these high temperatures is gaseous radiation due to the various quantum levels of molecular vibration and to the excited states of the atoms, ions, and electrons.

Non-equilibrium states of the gas add to the complication of high temperature problems. As the air flows through a normal shock or into the boundary layer, the molecules must be adjusted to the added degrees of freedom that correspond to the increased temperature. These adjustments take place by means of molecular collisions and collisions between dissociated atoms.

The number of required collisions is different for each degree of freedom, and thermodynamic equilibrium is approached gradually as each of the various relaxation processes is completed. The possible influence of non-equilibrium states is indicated by the fact that relaxation lengths for dissociation may reach several feet, the exact value depending on the pressure and the temperature.

Because of the extensive influence of the various real gas phenomena, they must be taken into account in engineering analyses of the aerodynamic and thermodynamic characteristics of a hypersonic vehicle. It is apparent that such analyses will include many more factors than at low speed. The state of the gas is now a complex function not only of pressure and temperature but also of reaction time, and the various transport properties that govern heat transfer and skin friction are affected.

Even though a surface is cooled, either by radiation or by artificial means, the temperature within the boundary layer is sufficiently high to

produce significant departures from perfect gas behavior. Additional mechanisms for heat transfer in the boundary layer now include gas radiation, mass diffusion due to concentration gradients, and possibly recombination of dissociated molecules at a cooled surface.

In a ramjet engine, combustion characteristics are complicated by the presence of the various degrees of freedom of the gas that are active at high temperature, while real gas effects on heat transfer at the walls of the combustion chamber and nozzle are amplified by the higher temperatures due to combustion and by the additional chemical species. Finally, relaxation effects become significant in the exhaust nozzles of both rockets and ramjets, for the degree to which chemical equilibrium is maintained during expansion through the nozzle can have a major influence on engine thrust.

A thorough knowledge of the fundamentals of gas behavior is therefore essential to the engineer who is to attack such problems as aerodynamic heating, re-entry of a ballistic vehicle, and hypersonic engine performance. Not only must analyses of these problems be developed, but they must be applied and interpreted. Furthermore, exact analysis of all the contributing factors is often impractical, and engineering approximations and simplifications must be made. The necessity for approximations is particularly acute in view of the many physical mechanisms about which little is known.

High Altitude Effects

High speed flight with rocket propulsion is complicated also by the effects of extreme altitudes in the case of such vehicles as long range ballistic missiles, sounding rockets, and earth satellites. Much attention will therefore be focused on flight at altitudes above 100,000 feet. At 300,000 feet the mean free molecular path is about one inch, and can easily be of the same order as the boundary layer thickness on a high-speed vehicle; at 500,000 feet altitude, the mean free path has increased to 10 feet, and becomes of the same order as the major dimensions of the vehicle (2).

Under these conditions the flow no longer behaves entirely as a continuum, and aerodynamic and heat transfer analyses must include the kinetic theory approach wherein the flow is treated as an assembly of discrete particles. Slip flow is characterized by a molecular mean free path greater than 1% of the boundary layer thickness; here continuum analyses can still be used with appropriate modifications.

True free-molecule flow, where a continuum approach is completely invalid, is assumed to occur when the mean free path exceeds a significant dimension of the body or wing of the vehicle. A new sub-field of aerodynamics, termed super-aerodynamics, has developed around the studies and observations of the flow in these regimes.

Propulsion

In the search for higher thrust levels and for increased specific impulse, the aeronautical profession is investigating a wide variety of rather unconventional methods of propulsion. Free-radical fuels offer the possibility of increased exit velocities due to higher combustion temperatures than can be obtained with conventional fuels. A nuclear reactor would provide a heat source having a neg-

ligible fuel rate, and would thus be advantageous for long range flight.

Finally, the ion rocket has been proposed as a means for obtaining low thrust levels over a sufficient duration of time for effective application to space vehicles. In this scheme a gas is ionized by an electrical discharge and accelerated by some means such as a linear accelerator to velocities many times higher than can be obtained by chemical reactions.

The ultimate propulsion system is one that would provide thrust without the necessity of transporting the mass from which a momentum reaction is obtained. As an approach toward this objective the photon rocket has been suggested. The photon rocket would operate on the Einstein principle of mass and energy equivalence. Thus the intense heating of a large surface of a vehicle would result in the conversion of mass to radiant energy, and sufficient thrust might be produced to sustain the flight of an astronautical vehicle.

The feasibility of such a device has yet to be proven (3), but this type of system is representative of the basic thinking that is being applied to hypervelocity propulsion. Kantrowitz, for example, mentions the possibility of applying a magnetic force to the ionized air behind a normal shock at Mach numbers over 15 (4).

The aeronautical engineer is not generally concerned with the design and development of propulsion systems. Because of the intimate relationship between powerplant performance and vehicle performance, however, he must understand the fundamental principles and operating characteristics involved. A typical example is the propeller of the reciprocating engine, a classical part of aeronautical engineering.

Often the choice of powerplant influences the overall design of the vehicle, as in the case of a nuclear power source, where shielding requirements and the influence of radiation on structures and equipment would be prime factors in the vehicle design concept. And with the more advanced systems, such as those making use of photon principles and magnetic fields, the engine and the airframe become a single piece of equipment.

Relativity Effects

Relativity concepts have been of no consequence in the time and distance scales with which the flight paths of yesterday and today are measured. With satellites and space vehicles, however, relativity effects can become significant. Investigations are currently in progress on such subjects as the use of earth satellites to obtain a check on theories of relativity (5), and the time scale to which life on a space vehicle must be referred. Though perhaps the realization of long range space flight may lie in the far distant future, such topics are part of the climate of modern aeronautics.

Physics and High Speed Flight

The problems of high speed flight that have been mentioned here indicate the broad extent to which advancements in the aeronautical technology must draw from the field of physics. Methods of aerodynamic and thermodynamic analysis will make use of the laws and principles of atomic physics, while propulsion performance and space flight mechanics will incor-

porate concepts and discoveries in nuclear physics and relativity.

This close relationship between physics and the aeronautics of high speed flight does not imply that the assembly of engineering analyses from the basic physical relationships is the responsibility of aeronautical engineering alone. In the case of real-gas effects, for example, tables and charts of gas properties and equations of state are already being made available by the various scientific research agencies.

Nevertheless, the engineer must understand the fundamental laws and techniques of the applicable branches of physics if he is to make the required observations, interpretations, and approximations so necessary to his art. Engineering calculations, moreover, may now include such factors as the Boltzmann constant and the Maxwell distribution, and quantum effects may appear directly in the mathematical reasoning for practical problems. The research engineer must go further, for often he will be involved in the investigations of basic physical behavior.

There are, of course, many problems of high speed flight that have not been touched upon. High temperature structures and materials, aerothermo-elasticity, automatic navigation and control, communications, and auxiliary power are additional areas that call for fundamental knowledge.

A typical example of the importance of fundamentals is to be found in the aerodynamic analysis of airplane performance. Aerodynamicists long accustomed to the design of low speed aircraft were suddenly confronted by problems of compressibility as speeds were extended through and beyond the velocity of sound. Various new phenomena were encountered, such as center-of-pressure shift, and the differential equations that described the flow became vastly different.

Yet comprehension of the fundamentals of fluid mechanics and thermodynamics enabled the aerodynamicist to adapt himself to the analysis and design of transonic and supersonic vehicles. At the same time, understanding of the basic mechanism whereby pressure disturbances are propagated through a fluid medium has led to the varied theoretical techniques of transonic and supersonic aerodynamics. It can be anticipated that a similar pattern will be followed as flight speeds increase and different factors assume a controlling influence.

The convergence of physics and aeronautical technology is well illustrated by the topics of current research. Investigations of high speed phenomena were initiated on a major scale by the hypersonic wind tunnels, low-density tunnels, and shock tubes that are becoming standard equipment for experimental aerothermodynamics. Now that the field of high speed research is established, a significant fraction of the engineering literature contains reports on such topics as the influence of dissociation on heat transfer, non-equilibrium phenomena, and free-molecular flow.

At the same time, research in physics is being directed toward the problems of high speed flight. Bethe and Teller (6) made a pioneer contribution to the influence of real gas behavior on the properties of a normal shock; Schwartz and Eckerman (7) have recently studied the relaxation process behind a normal shock; and Bond (8) has described the detailed

physical and chemical aspects of heat transfer at the nose of a ballistic missile.

Effect on Education

High speed flight imposes a new challenge on the aeronautical engineering educator. The engineering courses of today are already taught as scientific disciplines rather than as the so-called practical courses that were once predominant, and provide a rational framework upon which expanded technologies must be built.

Thus fluid mechanics would be extended to take into account the details of gas kinetics, and macroscopic thermodynamics would include statistical approaches. The broader courses in engineering analysis must be accompanied, however, by the addition of new fundamentals.

The principles of atomic physics, including kinetic theory, statistical mechanics, classical and quantum mechanics, and the related sub-fields, are becoming necessary additions to the aerodynamic and thermodynamic curricula in aeronautical engineering, and an introduction to relativity theory would definitely be to the student's advantage.

Nuclear physics is still involved only to a rather limited extent in aeronautics, but the basic concepts might well be included in the educational program. The presentation of the branches of physics that are directly applicable, particularly atomic physics, would ideally be much more intense than is usual in college physics for engineers. Such a scheme as including atomic physics in an elected major course in hypersonic aerodynamics may be the answer to an already overcrowded schedule.

Conclusion

The aeronautical sciences become increasingly complex as the dimensions of flight, reckoned in terms of speed and distance, become greater. Certainly a single individual cannot master all of the fields of knowledge that contribute to the aerodynamics and thermodynamics of high speed flight alone. The present age is one of specialization, and aeronautics is no exception. Only by applying the efforts of all the branches of engineering and the physical sciences will the problems of high speed flight be solved.

The educator is thus faced with the difficult choice of training specialists for each of the many subdivisions of aeronautics, or of presenting the fundamentals with which the engineer can later adapt to one specialized field or another. Because interests change and responsibilities grow during the course of a professional career, the latter choice would appear preferable.

Further, it is worth noting that not all aeronautical engineering activity will be directed toward high speed flight, for the design and development of conventional vehicles will continue to absorb a large share of engineering effort. Certainly, too, the extent of high speed flight is dictated by such unpredictable factors as economics and world politics.

Yet the horizons of flight are broad, and new advances are constantly being made in flight technology. The engineer must not be limited by ignorance of the fundamental principles upon which these advances depend. Regardless of later specialization, therefore, the basic concepts of the physical sciences will be significant contributions to his professional de-

velopment, and should be presented as such.

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TERMAN AND PETTIT APPOINTED

Frederick E. Terman, Stanford University Provost and Dean of the School of Engineering, has been elected 1957–58 chairman of the Naval Research Advisory Committee, the senior scientific group of the U. S. Navy. A member of ASEE since 1945 and Vice President, 1949–51, Dean Terman succeeds Julius Stratton, Chancellor of Massachusetts Institute of Technology. Appointed by the Secretary of the Navy, the Committee of 15 civilians preëminent in the fields of science, research, and development assists the Secretary, the Chief of Naval Operations, and Chief of Naval Research.

Also from Stanford, Professor Joseph M. Pettit, Associate Dean of the School of Engineering and a member of ASEE since 1940, has been appointed to the Army Scientific Advisory Panel. Under the chairmanship of President Frederick L. Hovde of Purdue University, the panel advises the Army on all phases of scientific research and weapons development.

GRAPHIC SCIENCE

Analysis—Synthesis—Communication

Sponsored by the Engineering Drawing Division
Editor: Eugene G. Paré, Washington State College, Pullman

FORESHADOWING OF EVENTS IN ENGINEERING AS RELATED TO GRAPHICS INSTRUCTION

L. E. GRINTER

Past President, ASEE; Dean of the Graduate School, University of Florida, Gainesville

The officers of the Drawing Division have asked me to express my thoughts on the needs of future engineers that should be met by the teachers of engineering drawing. These thoughts, I have found, agree with those of many drawing teachers, as well as industrial people.

My belief that an evolutionary change is occurring in the teaching of engineering drawing stems from several sources. One is a long experience in the teaching of courses that utilize the broad knowledge gained in freshman drawing. Another source is the industrial viewpoint stated by a panel of large-industry and government representatives at a 1955 meeting of the Evaluation Committee in Atlanta, Georgia.

This panel was clearly of the opinion that we should include in our freshmen drawing courses whatever techniques would be needed by the student in the work of the junior and senior years. The industrial representatives accepted without question industry's responsibility for any additional drafting training that might be needed after graduation.

While it is self-evident that one could not obtain this same reaction from chief draftsmen or from assistant chief engineers responsible for the production of enormous numbers of detail drawings, the panel members were reporting on the total needs of their organizations. It is these total needs which are broadly indicative of engineering employment, for as was mentioned, large industry and government employ the great majority of all engineers.

A second point of significance is that engineers of the future are less likely than are engineers today to be engaged in the actual production of detail drawings. Merely the shortage of engineers is forcing industry to provide assistants, and the draftsman is perhaps the most useful as well as the most easily trained assistant. All engineers must, of course, be able to understand drawings and be able to direct the efforts of the draftsman. It is conceivable that these abilities could be taught without personal participation in the process of making drawings being required as a part of the learning process, but I doubt that

the elimination of all drawing assignments would prove efficient in the use of a student's time.

One notes, however, that sketching or free-hand drawing is the technique by which nearly all engineers exchange ideas that do not require mathematical expression. It is also a technique much employed by engineering students. But only one engineer in five has an appreciable facility in using realistic free-hand pictorials, while far too few have a capacity for simple free-hand drawing that might prove acceptable for a typical industrial or student report.

As long as it was assumed that each engineer might be expected, on his first job, to serve as his own draftsman, little time could be found for instruction in graphical communication, as distinct from mechanical drawing. If the viewpoint is adopted that mechanical drawing must be understood rather than practiced, there may be much more opportunity to give instruction in the more basic concepts of graphical communication.

Another point comes to my mind in regard to the increasing importance of free-hand drawing. In the past a report was duplicated far less frequently, and far more formally, than is normal today. We are now so convinced of the importance of rapid communication that we duplicate an enormous amount of technical material quite informally. Machines are readily available to reproduce carbon lines at a moment's notice. This informality of duplication is gaining acceptance for comparable informality of the material duplicated. Pencil sketches are used in such material and handwritten notes and calculations are accepted. Unquestionably, the teacher of graphics who taught students how to present such material in clear, neat form, for easy communication without the aid of formal drafting techniques, would do a great service.

The revision of a course as basic as engineering drawing cannot be achieved overnight. In fact, it would doubtless be a great mistake to attempt to overthrow the concepts of a generation of teachers of whom we are justly proud. However, events do cast their shadow before them, and the new prestige of the engineer is bringing him the technical assistance that makes it unnecessary for him to be a practitioner of drafting.

As the engineer moves out of the area of personal use of mechanical drawing, his changed position will cast the shadow of his changing needs over departments of engineering drawing, as well as all other parts of the college of engineering. Evolution, not revolution, is desirable, but revolution results when evolutionary processes are artificially delayed. The Engineering Drawing Division of ASEE can contribute to the evolutionary process by gradually adjusting the objectives and ideals for the teaching of engineering drawing into conformity with the changing activities and responsibilities of engineers.

SUMMER EMPLOYMENT

The January issue of the JOURNAL will contain a Directory of Summer Faculty-Employment Programs. This directory, by Professor Clyde E. Work of Rensselaer Polytechnic Institute, will be of interest to those who are planning to participate in one of the available programs.

. . . . . YET-ITUDES

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

HAROLD A. FOECKE, Chairman
University of Notre Dame

ROBERT D. LARUE, Editor
Colorado State University

ON TEACHING ENGINEERING TEACHERS TO TEACH

CHARLES SÜSSKIND

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Also published, with permission and in slightly different form, by *Improving College and University Teaching* and the *American Journal of Physics.*

Even though he be that *rara avis* who attends all meetings of the Society faithfully, participates actively in the discussions at the meetings, and reads every copy of the JOURNAL from cover to cover, the young engineering teacher is nevertheless struck by the dearth of information and guidance on the one subject that should be uppermost in his mind: What must he do to become a more effective teacher? He has heard that teaching is an art, and not a science; for the rest, he might have seen the booklet that was published under the Society's auspices a few years ago (1), which contains some extremely useful hints (particularly with regard to the purely mechanical aspects of classroom presentation and allied problems), or some similar monograph—and then he is on his own.

He might ask his elders, with engaging naïveté, whether there is anything to be learned about college teaching from the professional "educationists"—the professors at the nearest School of Education, which is often on the same campus. He will quickly find that the estimate of these worthies in the minds of most other college professors runs the gamut from "harmless" to "useless" or "dangerous"; he might possibly hear the witticism in which a famous teachers' college is maligned as the place where artificial pearls are cast before real swine.

Even if his mentors are seriously inclined and well-read men who are up on the latest in the world of education, they will more likely than not refer our neophyte to the works of Dr. Bestor (2), chuckling at the way the good doctor lights into the said educationists. By now, the young engineering teacher is thoroughly mystified, and is beginning to wish that a formal course of instruction in the methods of teaching had been part of his graduate curriculum.

A Widespread Need

He need not feel lonely, at any rate: all new college teachers in all aca-

demic disciplines are, with a few exceptions, in the same boat. Nor is the situation a new one. In his inaugural oration as first president of Johns Hopkins University in 1876, Daniel Coit Gilman expressed the pious hope that graduate schools would help to develop the teaching ability of future professors. This hope has remained largely unfulfilled to date. In more recent years, the President's Commission on Higher Education (3) has bewailed the fact that "college teaching is the only major profession for which there does not exist a well-defined program of preparation directed toward developing the skills which it is essential for the practitioner to possess."

By and large, the colleges agree that something ought to be done. The University of Chicago's Committee on the Preparation of Teachers, in tabulating responses from 363 collegiate institutions, reported (4) that "the large majority of the respondents believe that definite instruction in the art of teaching ought to be given as part of the graduate program of the prospective college teacher." Still more recent investigations, such as those carried out under grants from the Ford Foundation's Fund for the Advancement of Education, echo these sentiments.

The engineering profession is singularly fortunate in having an effective organization at its disposal that could initiate, and perhaps even help to implement, such a program. In helping to establish it at the various colleges, the Society might well begin by pointing out that certain elements of the program already exist at virtually all institutions where graduate students participate in instruction. Here are some of the elements, listed in probable frequency-of-occurrence order:

1. *Supervision of laboratory instruction.* In the majority of engineering colleges, a senior faculty member is in charge of the laboratory, and is frequently present during at least part of the laboratory period.

2. *Regularly scheduled conferences between graduate assistants and senior faculty members.* Such conferences, whether formal or informal, provide an excellent opportunity for the prospective teacher to ask questions about the techniques and methods of his chosen profession, subject only to the senior man's ability and willingness to give the answers.

3. *Supervision of recitation periods and of classroom instruction.* This element is found more rarely; its absence is in most cases due to indolence, but often also to genuinely felt distaste (largely unjustified) for anything that smacks of interference with academic freedom. Needless to say, the presence of a senior faculty member in the classroom is sure to affect the performance of the lecturer under scrutiny—either adversely or beneficially—and the monitor must learn to allow for the perturbation that he causes merely by being there. A frank critique after the lecture cannot prove to be anything but helpful, especially if the advice is administered tactfully and mingled with praise; nothing will perk up a beginner like a pat on the back. (This approach has been tried and reported in the JOURNAL by the Air Force Institute of Technology, Vol. 47, No. 9, May, 1957, p. 745.)

4. *A teaching seminar, for the discussion of teaching methods and allied topics.* Only a handful of colleges have anything like it; where such a scheme exists, it depends almost entirely on the initiative and en-

thusiasm of the younger faculty members, who must take time out from research and from teaching and other duties to participate. Nevertheless, this is a very useful method of introducing the importance of the subject to future teachers, and of helping them to learn something about their profession.

5. *A formal course*, as described below, with provisions for discussions of the theory and practice of teaching, and for criticism of each participant's teaching effectiveness, as exhibited in actual presentations to the class. It is the writer's firm conviction that this is the most effective way to improve the teaching skills of the large body of new instructors who are turned loose on our college population annually.

Sequence of Steps

The above schemes might be considered as forming a five-step ladder, with each successive step encompassing most of the features of the step below. To develop the teaching abilities of future professors, every institution engaged in graduate instruction should strive to climb this ladder step by step. The more vigorous might even find it possible to take it two steps at a time.

The top of the ladder, then, is a graduate course, to be assigned fully as much credit as other graduate courses, with perhaps two meetings a week, conducted by a senior faculty member (or a committee made up of the members of several faculties), quite probably *not* from the School of Education (though perhaps with visiting or consultation cooperation). The course might be required of all graduate assistants participating in the teaching program, and would be at least strongly recommended for all doctoral candidates who do not fall into this category but propose to make teaching their career.

New faculty appointees with the rank of assistant professor and below who had not themselves gone through such a course when they were graduate students might be required to participate even on the post-doctoral level. Simulation of lecture-room conditions would be an important concomitant of such a course, and each participant would be asked to "perform" repeatedly so that his performance could readily be criticized and evaluated by his fellow students and faculty supervisors.

Though such a course might originate in an engineering department, to the greater glory of its faculty, the course need not and probably ought not be restricted to engineers, because of the obvious additional benefits that would result from discussions among teachers from widely differing fields.

Oregon State College has gone perhaps further than any other institution toward reaching the top step of this ladder. In fact, O. S. C. may have actually gone a step beyond, for not only has a graduate seminar on teaching procedures been established there (5), with enthusiastic participants from various fields, but a minor in College Teaching has also been made available that provides an unprecedented opportunity for prospective college teachers to concentrate on learning their profession.

The adoption of courses on teaching procedures by many schools would be an extremely valuable complement to the recently proposed annual summer school for young engineering teachers (6), because such seminars would provide a convenient outlet for dis-

seminating the knowledge gained at the summer schools.

The existence of a formal course as proposed above would also offer administrators a more reliable means of evaluating the teaching performance of prospective instructors and new faculty members. Contact during the course, coupled with close supervision in teaching assignments, would make possible much more exact evaluations of a candidate's teaching ability. Present methods of evaluation can result in a little more than a few neutral remarks about personality and research ability.

Another important advantage of the proposed course (with graduate credit) would be the increased stature and attractiveness it would give to teaching assistantships. This advantage is particularly important at the present time when the number and attractiveness of research assistantships and fellowships is also on the increase, with the attendant danger that the most capable students may by-pass teaching opportunities altogether, to the everlasting detriment of engineering education.

Precautions

It might not be amiss to mention some of the possible difficulties with the type of course proposed. Teaching assistants should not get course credit for their actual teaching assignments. Most schools have rules against students receiving pay and credit for the same activity; such rules should be strictly enforced in the present instance, and teaching assistants should be made to enroll in a separate, formal course. A further danger exists that, unless the students are drawn from many different departments as suggested above, such a course could degenerate into a mere discussion of forthcoming classroom or laboratory assignments.

But the dangers are certainly avoidable and are insignificant compared with all the possible benefits from such a course. Those who would object to adding yet another demand to the already crowded graduate programs should be consoled and reassured by the realization that the proposed course is fully in line with the trend toward less specialized and more basic courses—for what is more basic for a college teacher than the ability to teach?

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With permission of the JOURNAL, and in slightly different forms, the content of this article has also been published by *Improving College and University Teaching* and the *American Journal of Physics*.

REPORTS OF ASEE OFFICERS

for 1956-1957

REPORT OF THE SECRETARY

W. LEIGHTON COLLINS

1. *Finances.* The *pro forma* statement for 1956–1957 indicates a favorable balance of about $8000 for the year's operations. Increased income in all categories more than offset the increased *Journal* costs. Income for 1956–57 increased over the previous year by about $8500; and was about $11,000 over the budgeted amount. Disbursements for the year almost equalled the budgeted amount and exceeded last year's total by about $12,000. It is recommended that $10,000, from the year's surplus and unappropriated surplus ($12,371.68 on July 1, 1956), be transferred to the Reserve for Emergencies ($50,000 on July 1, 1956).

2. *Budget for 1957–58.* The proposed budget is a fairly tight, but realistic, one and is the largest in the Society's history—$105,750. It is based on a continued growth of the Society —a total gain of 800 new individual members, an increase of 10 industrial members, and an increase in advertising income of 15 per cent. This is made necessary by increased *Journal* costs and salary increases necessary to conform with the practices of the University of Illinois.

3. *Individual Membership.* During the fiscal year 835 persons joined the Society as individual members. 450 have joined since the *Yearbook* went to press. Some statistics for the year, with similar figures for the past two years, for comparison, follow:

	54–55	55–56	56–57
Yearbook, individual membership	7,560	7,548	7,490
New members	472	639	835
Life members	16	23	9
Resignations	250	297	210
Deaths	42	51	45
Delinquent one year's dues	917	352	364
Delinquent two years' dues and to be dropped	99	266	181
Address unknown, not to be dropped	33	73	13
Applications to be approved at Annual Meeting	54	85	20
Individual dues	$49,652	$53,343	$54,365

The total individual membership as of 6 June is 7986. After the appropriate actions at the Annual Meeting the total will be 7575. It is apparent that the efforts of the YETS were more successful this year than last, but according to the institutions for which names of representatives were sent to ASEE headquarters a membership campaign was conducted in only about 30 per cent of the member institutions.

Certified letters were sent to 178 members who were two years delinquent in dues and for whom drop action was to be taken; 337 were mailed last year. Of the 178, 4 have paid, 2 have resigned, and 17 were unclaimed. The drop action at the Annual Meeting will eliminate all two-year delinquents, including those with addresses unknown.

4. *Institutional Membership.* Changes for the year are given below:

	54–55	55–56	56–57
Active	150	149	148
Associate	109	123	141
Affiliate	28	36	39

The number of Associate members discontinuing membership during the year was four, and one has not paid dues. One Active member also is one year delinquent in dues.

5. *Subscriptions.* The Executive Board approved increases in subscription rates for the *Journal* for next year because of the increased costs of printing the *Journal.* The new rates, with the old ones in parentheses, are $10.00 ($6.00) per year; foreign $11.00 ($7.00) per year; *Yearbook* $7.50 ($6.00) per copy; single copies $1.25 ($1.25); *Proceedings* $7.00 ($6.00) for members and $9.00 ($7.00) for nonmembers. Subscription rates traditionally have been higher than dues in order to encourage membership in the Society. There are about 500 subscriptions at the present time, most of them being libraries; about half are foreign.

6. *Journal of Engineering Education.* The JOURNAL came out in the proper months during the last half of the year as a result of having two issues printed elsewhere than at Lancaster Press. Manuscripts now are being submitted in reasonable quantity and Divisions and Sections are more fully realizing their responsibilities in maintaining a flow of material. Some of the papers, however, have much to be desired insofar as quality is concerned. Printing costs increased greatly during the year, but some savings resulted from uniformity of signatures. The major problems now are satisfactory scheduling and a reduction in the delay time between submitting material and mailing. This means reaching a workable agreement with Lancaster Press based on when we get most of our material, when we would like to have the *Journal* mailed, and what Lancaster is able and willing to do. To offset increased printing costs and to more nearly conform with other journals, new advertising rates were approved by the Executive Board. The increases average about 50 per cent and will go into effect with all new contracts and renewals. The amount of advertising during the year increased over last year, and extensive efforts will be made during the year to increase the amount further.

7. *Personnel Needs.* The need for a full-time employee to replace the part-time student help is urgent. The budget for 1957–58 continues the part-time help, but it is hoped that during the year a full-time person can be employed. A possible allocation of duties would be to have this new person handle the clerical aspects of the *Yearbook,* news releases, and the Annual Meeting program. This will permit the Editorial Secretary to spend more time on production of the *Journal* and advertising, and enable the Office Secretary to spend more time on planning work, helping the Secretary, and relieving him of more letter writing. This is the major current personnel need, and has become acute because of the large number of special projects and our increased public relations activities, and continued high level of special studies. As soon as JOURNAL costs and the advertising income for next year have been determined for 2 or 3 months it is hoped this position can be filled.

8. *Secretary's Travel.* During the year the following meetings and conferences were attended by the Secretary. It should be noted that only two EJC Board meetings, none of the monthly meetings of EJC's Committee of Society Secretaries, none of the EJC membership committee meetings, and no Section meeting (other than routine ones) were attended. It is thus apparent that the Secretary has not participated in EJC responsibilities as fully as he should.

Sept. 5–8. Deans' Conference, Gatlinburg, Tennessee
Sept. 15. Executive Board, Chicago, Illinois
Oct. 11–12. American Council on Education, Chicago, Illinois
Oct. 25–27. ECPD, Executive Board, and General Council, Detroit, Michigan
Nov. 12–15. Land Grant Association, Washington, D. C.
Dec. 2–4. Evaluation Follow-Up, University of Michigan
Jan. 13–15. EJC National Education Conference, Gould House of New York University
Jan. 15. Council of Engineering Society Secretaries, New York City
Jan. 16. EJC Board, New York City
Jan. 17–18. EJC General Assembly, New York City
Jan. 18. EJC Board, New York City
Jan. 31–Feb. 1. Drawing Division Meeting, Rice Institute
Feb. 13. Air Force Institute of Technology Branch, Dayton, Ohio
Feb. 14. Conference with J. I. Mattill on public relations, Chicago, Illinois
Feb. 22–23. Atomic Energy Education Committee, Argonne National Laboratory
Feb. 28. ECRC Executive Committee Meeting, Chicago, Illinois
Mar. 4–5. National Conference on Higher Education, Chicago, Illinois
Apr. 12–13. Local Committee, Cornell University
Apr. 26–27. Executive Board and Ohio Section, University of Toledo
May 9–11. Inauguration of new chancellor and conferences with 1959 Annual Meeting Chairmen, University of Pittsburgh
May 18. Illinois-Indiana Section, Northwestern Technological Institute
June 15–22. Annual Meeting, Cornell University

9. *Insurance.* During the year the Executive Board noted that the Society should take out liability insurance to protect itself in case of accidents at any of its meetings. This is in keeping with the practice of other engineering societies. In addition, workmen's compensation insurance was taken out to cover the headquarters staff, and non-ownership automobile insurance to protect the Society when anyone is driving on Society business.

10. *Revision of Constitution.* All previous studies of the Constitution and By-Laws were assembled during the year. Particular attention was given to the "grass-roots" suggestions, to the modernizing of the Society's structure and the speeding of its processes and actions, to redefining classes of members, and to conform with present practices of professional organizations. The referendum vote indicated an overwhelming approval of the changes. Of the 17 proposals, 8 received no negative votes, 8 received 1

negative vote, and one (ownership of papers) received 3 negative votes. Since a total of 92 ballots were cast, and since "at least two-thirds of the ballots returned within thirty (30) days after they were mailed out were favorable" (as required by the Constitution), all changes were approved. The revised constitution is published in the April, 1957 issue of the JOURNAL OF ENGINEERING EDUCATION. The four changes in the By-Laws, printed in the same issue of the *Journal*, will be voted on at the Annual Meeting. The Society will operate under the new provisions next year. The most significant change probably is the new method of electing officers.

11. *Public Relations.* With the fine cooperation of John Mattill about ten special news releases were prepared and mailed out during the year. Up to 2000 of each were mailed to deans of engineering, directors of research, Society officers and committee, division, and section chairmen, technical publications, education editors, etc. This has been done in lieu of the President's News Letter. The success of the efforts is evidenced by the increasing number of clip sheets from other organizations now being received.

12. *Industrial Fellowships.* The second Leeds and Northrup sponsored fellowship was awarded to the University of Washington and the first was extended another year at Johns Hopkins University. Promotional activity is required if this plan is to be extended.

13. *YET Paper Contest.* Despite the increased efforts to promote the contest, only 12 of the 16 Sections submitted papers in the national contest. One paper was submitted too late for consideration, and for at least two Sections the papers submitted were the only ones entered in Section contests. The national judging committee considered most of the papers to be of good quality, which is an improvement over last year. The rules for judging prepared by the national committee were distributed to all Sections and published in the March 1957 issue of the JOURNAL OF ENGINEERING EDUCATION.

14. *Summer Schools.* The only Summer School is the one on surveying sponsored by the Civil Engineering Division and being held at Camp F. W. Welch of the State College of Washington at Naches, Washington on August 5–9. It is designated as the Fourth National Surveying Teachers Conference.

15. *Mid-Winter Meetings.* The Relations With Industry, Drawing, and Cooperative Engineering Education Divisions held their usual meetings. RWI met at the University of California at Los Angeles on January 30 and 31, the Drawing Division at Rice Institute on January 31 and February 1, and the Co-op Division at Northeastern University of January 10 and 11. The RWI's College-Industry Conference was singularly successful and indicated a high level of industry's interest in the affairs of ASEE.

16. *ECAC.* The relationship between the General Council and ECAC should be improved by virtue of its Secretary becoming a member of the General Council. The Military Affairs Committee has been extremely active, and the International Relations committee has been particularly helpful to the Secretary. Two particular problems referred to ECAC during the year by the Executive Board are the extent to which ASEE should develop the interests of student advisors, and to what extent should ASEE study the

reasons for termination of college educational programs for reasons other than graduation.

17. *ECRC.* The relationship between the General Council and ECRC should be improved by virtue of the Secretary of ECRC becoming a member of the General Council; a wholesome integration of efforts and understandings should result. The biennial Review of Current Research and Directory of Member Institutions is now in press. The Executive Board has asked ECRC to study the publication of the Review from the point of view of making it self-supporting by increasing the selling price, including advertising, etc.

18. *New Publications.* The only new publication during the year is Recruiting Practices and Procedures. It replaces and brings up to date the Code of Ethics published in 1949. The Society is indebted to the Midwest College Placement Association for the initial preparation of a code for interviewing which led to the preparation of Recruiting Practices and Procedures by the Committee on Ethics. Publication was financed by money from the unappropriated surplus, but the amount is to be returned from the income from sales.

19. *Projects*

a. *Evaluation of Engineering Education Follow-Up;* B. R. Teare, Jr., Chairman. The six *ad hoc* committees on the engineering sciences and the committee on Analysis and Design held two-day meetings at the University of Michigan in December. Preliminary copies of reports were drafted and discussed by all in attendance. The Chairman will present a summary of these reports at the Annual Meeting and a limited number of mimeographed copies will be available for distribution. Two additional Industry-Education Conferences to discuss the Evaluation Report also were sponsored, one in Detroit and one in New Orleans.

b. *Humanistic-Social Research Follow-Up;* G. A. Gullette, Chairman. The Steering Committee was unable to develop plans soon enough to meet the National Science Foundation's deadline for request for funds, but has met and will submit a definite proposal for a 1958 Summer program at the Annual Meeting.

c. *Graduate Study Project;* N. A. Hall, Chairman. An interim report will be presented and discussed at the Annual Meeting.

d. *ECRC Survey of Engineering Colleges' Research Capabilities;* E. A. Walker, Chairman. Plans are completed and interviewing teams are ready to gather the data this summer.

e. *Educational Requirements for Engineers In the Nuclear Industry;* Glenn Murphy, Chairman. The failure of several attempts at financing resulted in a curtailment of the project. A final report has been submitted to the Atomic Energy Education Committee. The Nuclear Energy Education Newsletter also was discontinued during the year due to a lack of funds. It now seems reasonably certain that the Atomic Energy Commission will finance the publication next year.

f. *Survey of Technical Institute Education;* K. L. Holderman, Chairman. The survey has progressed on schedule; the field work is completed and the data are being digested. A progress report will be presented at the Annual Meeting.

g. *ASEE–AEC Summer Institutes on Nuclear Energy.* After great delay, the Atomic Energy Commission decided to sponsor the five institutes

listed below. The lateness of the decision necessitated operation on a "crash" basis, with the cart always ahead of the horse. As a result, the grant forms are still unsigned, as of 11 June 1957.

1. Basic Course—Brookhaven National Laboratory
2. Chemical Processing—Hanford Atomic Products Operation
3. Metallurgy—Ames Laboratory of AEC
4. Properties and Techniques of Operation of the Argonaut Reactor—Argonne National Laboratory
5. Reactor Theory—Oak Ridge National Laboratory

There were 64 applications for the 30 appointments available at Brookhaven. The real need is for a basic course and AEC *must* recognize this fact if it is sincere in its desire to aid in developing adequate engineering faculties. 34 of the applicants for Brookhaven were referred to the advanced institutes and a sufficient number were accepted to give the following attendance.

	Attendance	Capacity
1. Brookhaven	30	30
2. Hanford (Q clearance required)	8	16
3. Ames	23	25
4. Argonne	8	24
5. Oak Ridge	12	20

Of the 104 who applied, 81 have been accepted, 7 have withdrawn, 4 original applications for advanced institutes were not accepted, and 12 who originally applied for Brookhaven could not be accepted because of a lack of capacity. ASEE is administering the program under a contract with AEC.

h. *Technical Institute Book;* H. P. Adams, Vice Chairman. The death of A. L. Williston, chairman and benefactor, resulted in little progress during the year. The committee is meeting at the Annual Meeting and expects to develop plans for the future.

i. *Mathematics In Engineering;* F. C. Lindvall and G. G. Brown, Co-chairmen. Nothing has been heard during the year about the publication of the papers in the *Journal.*

j. *English In Engineering Curricula;* C. A. Brown, Chairman. Efforts have been made to secure financing by industry and by private foundations, but so far all efforts have been unsuccessful. One difficulty is the current discussion of the need for a comprehensive study of the teaching of English in all aspects of our educational system.

k. *Institute on Solid State Physics,* 1954. The book "Science of Engineering Materials" edited by Dr. J. E. Goldman is the proceedings of the institute and will be published this summer by John Wiley and Sons, Inc.

l. *Institute on Nuclear Science In Engineering Education,* 1954. A review of the papers resulted in the decision that no proceedings now should be published. The closing out of the project is under way.

m. *Development of Engineering Faculties;* H. L. Hazen, Chairman. An Executive Committee of five has worked diligently to get the project under way. Dr. W. H. Miernyk of Northeastern University is the Executive Director. Preliminary financing to the extent of $10,017 was by the National Science Foundation and since then three industries have contributed $1500. Additional funds are needed to continue the project. The proce-

dure followed was to first determine the dimensions of the faculty manpower problem by means of a questionnaire and all available references. Salary data obtained by Engineers Joint Council are now being studied. The next step will be to study possible programs of action which give promise of aiding engineering schools with their faculty staffing problems. It is believed that a professionally directed study of the motivations which cause engineers to choose teaching or non-teaching careers is needed, but since this research would cost $75,000 and require two years the study is being deferred.

n. *Scientific and Engineering Manpower Survey for Atomic Energy Programs;* L. V. McLean, Director. The Atomic Energy Education Committee is sponsoring this project. Up to 1000 institutions of higher education are to be contacted by questionnaire and the results made available to the Atomic Energy Commission. The questionnaire has been approved by all concerned and the contracts between ASEE, AEC, and Louisiana State University are now being drawn.

REPORT OF THE VICE PRESIDENT FOR SECTIONS AND BRANCHES

F. C. LINDVALL

An old story tells of the boy who was urged to keep a diary. His record for long stretches of time showed only the daily entry, "Got up. Washed. Went to bed." Nothing seemed worthy of mention beyond these routines. This report on Section activities is, hopefully, somewhat more informative.

This year we have good information with which to gage the scope and character of the Section meetings and activities, their value to the individual members and their significance to our Society as a whole. This information has come through the initial use of a report form, reproduced here, and the printed programs of the various meetings. For purely record purposes, the form is useful in consolidating for the Secretary's office the essential information on Section officers, committee members and Division liason members in more systematic form than in former procedures. Useful statistics on attendance, Section financing, and the YET Contest are now conveniently available. Any member's comments which might lead to improvement in reporting Section affairs are solicited.

Total reported attendance during the past year at Section meetings was 2038. Some Sections reported members in attendance separately with wives and guests in addition. The questionnaire is not specific. However, the total number of people directly concerned with discussion of engineering education problems is the significant quantity. The three Sections not reporting attendance figures could easily bring the total to 2500. For the reporting Sections the attendance figure was 27 per cent of the combined membership. In addition,

a substantial number of guests participated in the meetings and social functions. As would be expected, the lowest percentage attendance figures developed in the Sections having greatest geographical spread, although the character of the region and the presence of major industrial and population centers which provide numerous other contacts for engineering educators has much to do with interest in Section meetings. The Pacific Southwest Section attempts to overcome some of the travel handicap by holding two regional meetings during the year in addition to its annual meeting. The Middle-Atlantic Section reports two meetings in different locations this past year.

The duration of these meetings varies greatly from Section to Section. Two Sections held three-day sessions; five, two-day; and seven one-day meetings were reported. The National Capitol Area Section, essentially the metropolitan Washington area, held two evening meetings rather than a single, longer session.

Competition in the Section YET Paper Contest varied among the Sections from eight entries in one Section down to zero entries in two Sections. Three might be called a representative figure, one which suggests that further effort by the Section officers and the YET Committee is needed, particularly in those Sections where no entries were made, or only one. The Middle-Atlantic Section with eight entries is to be congratulated as is the very much smaller Pacific Northwest Section with four.

Sections finance themselves in various ways, as suggested in the Manual for Sections. Two Sections report dues of $1.00 and two others have institutional fees of $10 or $15 in lieu of members' Section dues. Eight Sections report registration fees for meetings varying in amount from fifty cents to $4.00. One Section indicated that the equivalent of a registration fee was included in a meal ticket. Evidently at present levels of activity the Sections can finance themselves in this modest and informal fashion. Any substantial expansion of Section work, particularly in those Sections covering large geographical areas, would require travel money in excess of that which individuals or their schools could pay.

After these statistical bits, we should ask, what did 2,500 people in some 17 meetings talk about? We can't reproduce here in complete detail the excellent programs of discussion. Members heard a few papers on new developments affecting engineering education, such as nuclear reactor design, and operations research. Broad educational topics were discussed and there was also opportunity for much "shop talk" along Divisional lines. The character of the meetings can best be judged by typical subjects of discussion.

- Nuclear engineering education
- The talented student at the high school level
- Attrition and what is being done about it
- Engineering and the basic sciences
- Engineering skills or scientific background
- Engineering education and the high schools
- Graduate study in engineering, experiences, research, night programs, accreditation
- Industry-Education relationships
- Community or Junior Colleges and engineering education

Value and cost of shop courses
Teaching methods and techniques
How to make teaching more attractive
Recruiting and its effects on teachers, students and scholarship
Professors on loan from industry
ECPD and the Civil engineering curricula
Technical Institutes
The place of high-speed computers in engineering curricula
Closed-circuit TV in college teaching
Professional development
Professional ethics

This sampling is far from being a complete list of topics which appeared on the programs of the Section meetings nor are the items the exact titles of discussion subjects. Evidently our members do not lack subject matter for meetings. It is hoped that this listing may be helpful as an interchange of ideas among the Sections.

As seen from these reports, the So-

SECTION REPORT FOR 1957 ANNUAL MEETING

Submit a copy to F. C. Lindvall and to the Secretary's office by May 1, 1957; for meetings in May, the reports must be mailed immediately upon the close of the meetings

Submitted by .....
Date .....

Name of Section .....
Chairman .....
Vice Chairman .....
Secretary .....
Executive Committee Members .....
YET Sub-Chairman .....
RWI Division Liaison Member .....
Physics Division Liaison Member .....
Other Liaison Members .....
Principal activity for year .....
Special features found of value .....
Place of meeting(s) ..... Date of meeting(s) .....
Host Institution(s) .....
No. of members in Section ..... Attendance at Meeting(s) .....
Section dues ..... Section meeting registration fee .....
Sessions, Theme, and Topics at Meeting (Please attach copy of printed program).
No. of entries received in YET Paper Contest .....
Section YET Paper Contest Winner .....
(Name and Institution)
Remarks .....
Suggestions .....
(Attach extra sheet if necessary)

ciety membership has been active this past year, through the Sections and Branches. The Branches are less formal and do not report, yet their influence and effectiveness is important, particularly among the younger teachers. The participation of members in Section meetings has been good as shown by attendance totaling 27 per cent of the membership. This is a measure of the vitality of the Society and of the serious interest in the problems confronting engineering education today. Those problems are not readily solved and new ones are continually being created by our expanding technology. Our Society has much with which to concern itself and in the Sections and Branches our thoughts and ideas can receive thorough consideration and full discussion. Then, through the National meeting and our publications, the significant conclusions and recommendations can come to the attention of the entire membership. We can anticipate another year of effective Section and Branch activity.

Report of the Vice President
FOR INSTRUCTIONAL DIVISIONS

C. A. BROWN

During the past year, emphasis has been placed upon strengthening the divisional organizations and activities. The first move in that direction was to hold a meeting of the divisional representatives at the time of the mid-year meeting of the General Council in Detroit. Out of that discussion at that meeting came the suggestion that one of the best ways of maintaining a continuity of leadership and planning was through an Executive Committee. A considerable number of the divisions already have such a committee functioning. Others have now established Executive Committees. Another outgrowth of that meeting was the publication of all of the names of the officers and committee members of each division in the Annual Directory.

Another means of strengthening the divisional organizations is through newsletters during the year. Recently a survey was made of the kinds of communication and their financing employed by each of the divisions with its divisional membership. That survey revealed the following:

Kinds of Communication. Four Divisions have publications that contain full-length articles. Seven Divisions send one or more newsletters to Divisional members. Eight Divisions do not send any newsletters or bulletins to their members. Three Divisions did not reply.

Financing. Newsletters for seven Divisions are financed primarily by the Society. Other methods of financing include support from the institution employing the Divisional Editor, advertising, proceeds from a summer school, and subscriptions.

Another aspect of divisional activity is that of planning for the Annual Meeting. This is the primary and certainly the most visible activity of a

division. There is always the need for long-range planning for programs beyond the immediate Annual Meeting. While it is true that the theme or topics covered at an Annual Meeting should be timely, there should be the assurance that all facets of the Division's interest will have received some attention or coverage over a period of years. This requires that the Program Committee or the Executive Committee be looking ahead for program ideas more than one year in advance.

Finally, we hope to improve the quality of individual meetings. Some of our meetings last year at Ames were criticized because papers were too laboriously "read" and there was too little time provided for participation and discussion. Methods of improving the meetings have been referred to several times this year in the JOURNAL. We hope that through the efforts of our program chairmen our speakers this year will "speak" instead of "read," and that there will be ample time at each meeting for discussion.

Report of

THE ENGINEERING COLLEGE ADMINISTRATIVE COUNCIL

RALPH A. MORGEN

Secretary

A. Officers and Committees

Officers of the Engineering College Administrative Council for 1956–57 were: Chairman, Dean William T. Alexander, Northeastern University; Secretary, Dr. Ralph A. Morgen, Purdue University.

Executive Committee members were: Dean James R. Cudworth, University of Alabama; Dean Harold E. Wessman, University of Washington; Dean Elmer C. Easton, Rutgers University; Dean Paul E. Hemke, Rensselaer Polytechnic Institute; Dr. J. Robert Van Pelt, President, Michigan College of Mining and Technology.

Committee Chairmen were: International Relations Committee—Prof. Harold W. Bibber, Union College; Military Affairs Committee—Dean J. Harold Lampe, North Carolina State College; Secondary Schools Committee—Dr. J. F. Downie Smith, Iowa State College; Selection and Guidance Committee—Dean Robert H. Roy, Johns Hopkins University; Manpower Committee—Dr. Donald L. Pyke, Ramo-Woolridge Company Committee on Accreditation by Individual States (*ad hoc*)—Dean Elmer C. Easton, Rutgers University.

B. Executive Committee Meetings

The Executive Committee held its fall meeting on October 25, 1956 at the Park Shelton Hotel, Detroit, Michigan. This meeting was held in conjunction with the annual meeting of the Engineers Council for Professional Development. At this meeting the program for the year 1956–57 was reviewed and the minutes of this meeting were circulated as Appendix B of

Bulletin XXI, Engineering College Administrative Council, circulated in May, 1957.

Subsequent business of the Council was handled by correspondence.

A luncheon meeting of old and new members of the Executive Committee is scheduled for Thursday, June 20, at Ithaca, New York.

C. Nominations and Election

At the November 1956 Executive Committee meeting the Nominating Committee was appointed by the Chairman, consisting of Dean William T. Alexander, Chairman; Dean James R. Cudworth; and Dean Harold E. Wessman. The nominating committee proposed the following slate: Chairman—Dr. Ralph A. Morgen, Purdue University; Secretary—Dean Harold E. Wessman, University of Washington; Executive Committee members—Dean Armour T. Granger, University of Tennessee and Dean Robert H. Roy, Johns Hopkins University.

One ballot was mailed to each member institution—153 ballots were mailed—112 ballots were returned properly marked—41 ballots were not returned.

Of the 112 ballots returned, 112 votes were cast for the slate as recommended initially by the Nominating Committee.

D. By mail vote the Air University Institute of Technology was admitted to ECAC membership during 1956.

E. By mail vote the proposed changes in the Constitution and By-Laws of ASEE were approved by members of ECAC. The vote was overwhelmingly favorable with no more than five negative votes to any one particular article or section change.

F. Committee Activity

As usual, most of the activity of the ECAC was conducted by its committees. A brief summary of the committee operations for 1956–57 is given below. The full report of each committee is in the files of the Secretary.

1. *Committee on International Relations*—H. W. Bibber, Chairman.

The Committee has acted as an information center on international problems for ASEE. When the Hungarian refugee problem became acute, efforts were made to help the situation through the activities of this Committee.

The Committee has sponsored a conference at Cornell on Thursday afternoon, June 20.

On Friday morning, June 21, the Committee has had a special session for international visitors. It is hoped that this could be the beginning of a series of annual gatherings for engineering teachers.

Although not directly connected with the activity of the committee itself, Dean Lee H. Johnson of Tulane, and Dr. Ralph A. Morgen of Purdue, attended the UPADI meeting in Mexico City in October 1956, as representatives of ASEE. The important outcomes of that meeting were recommendations for establishment of a permanent Committee on Engineering Education and for inclusion in the program of UPADI a session devoted to cooperation among the nations in engineering education.

2. *Manpower Committee*—Donald L. Pyke, Chairman.

The original purpose of this Committee was to look into the effect of selective service on the manpower

problem as it affects engineering students and new graduates. At the Executive Committee meeting in October 1956, this Committee was asked to review the situation in light of present day conditions. It is to bring a recommendation to the Executive Committee in June 1957 regarding the future course of the committee. At the present moment, it appears that the Committee will recommend continuation in one or more of the three following areas: (a) A closer liaison with EJC in connection with its annual review of supply and demand for engineers; (b) liaison between ECAC and the Engineering Manpower Commission of EJC; or (c) Consideration of the effect on future supply of engineering manpower of the gradual shift of qualified engineering educators to industry.

3. *Committee on Selection and Guidance*—Robert H. Roy and A. R. Hellwarth, Co-Chairmen.

The activities of the committee were divided into two areas:

(a) Continuation of the Engineering Graduate Placement Research with the Educational Testing Service. Additional sponsors were obtained and the complete list of sponsors now consists of American Telephone and Telegraph Company, Detroit Edison Company, B. F. Goodrich Company, International Business Machines Corporation, Westinghouse Electric Corporation; Sandia Corporation; Stromberg-Carlson Division of General Dynamics Corporation; and General Electric Company. Bendix Radio in Baltimore, a Division of Bendix Aviation Corporation, is now negotiating to join the program.

During the year the Educational Testing Service has tested approximately 1600 students at 11 different institutions.

(b) The Committee has been working with the National Science Foundation to supply speakers for the high school summer institutes being sponsored by the National Science Foundation. The purpose is to acquaint these high school science teachers with the needs of engineering. Several pilot programs will be tried this year to be used as a criterion for future planning.

4. *Committee on Secondary Schools*—J. F. Downie-Smith, Chairman.

The Secondary Schools Committee has prepared a report on the long range improvement of teaching of science and mathematics in high schools. This was published in the December 1956 issue of the JOURNAL OF ENGINEERING EDUCATION.

In order to implement the recommendations of this report, a conference was then arranged for the annual meeting of the ASEE on Monday, June 17, at 2:00 P.M. This conference has been sponsored jointly by the Secondary Schools Committee, the Selection and Guidance Committee, and the Relations with Industry Division. It is hoped that from this conference a clear picture can be obtained of what should be done by each group and who in the group should do it.

5. *Military Affairs Committee*—J. H. Lampe, Chairman.

The major efforts of this committee this year have been toward a solution of the NROTC problem. A joint ASEE-Navy study group has met several times during the year. The pur-

pose of this study group is to reconcile the viewpoints of the Navy and educators regarding the credits and objectives for undergraduate engineering education and the production of Naval officers. The Committee will sponsor a session at Cornell on Wednesday, June 19, at 2:00 P.M., to discuss the reserve officers' training problems.

6. *Ad Hoc Committee to Study Accreditation by Individual States*—Elmer C. Easton, Chairman.

The studies of this committee were centered on the practices of the State of New York. This is the only state which is conducting its own accrediting of engineering colleges.

After much careful consideration of the problem the committee concluded that the new Commissioner, Dr. Joseph Nyquist, was sympathetic to our request, that the duplicate accrediting procedure be abolished in favor of reliance on the work of ECPD. It also became apparent that there was an internal problem within the New York State Education Department which requires time to solve. For this reason the committee has withheld further action in order to give Dr. Nyquist time to resolve the internal problem amicably.

This situation in New York is being watched by this committee and by the National Commission on Accrediting. Further action will be taken only if there is evidence to indicate that the desired reform is not progressing.

G. Two ECAC Executive Committee Bulletins were circulated to the membership during the year 1956–57, Issue XX early in October 1956 and Issue XXI in May 1957.

H. Program of the Ithaca Meeting

The Council has sponsored the following program at the ASEE meeting at Cornell, June 17–21, 1957 inclusive:

1. Monday, June 17, 2:00 P.M. Committees on Selection and Guidance and Secondary Schools, a program on "A Longe-Range Improvement Program in Science Teaching for Secondary Schools."
2. Tuesday, June 18, 6:00 P.M. ECAC–ECRC Annual Banquet. The Speaker was Dr. Eric A. Walker, President of Pennsylvania State University, on the subject of "Research and Engineering Education."
3. Wednesday, June 19, 2:00 P. M. Program arranged by the Military Affairs Committee under Dean J. Harold Lampe.
4. Thursday, June 20, 9:30 A.M. The fourth general session was sponsored by ECAC on the subject of "Improvement of Engineering Education through Effective Utilization of Faculties and Facilities." Speakers —B. W. Owens, University of Washington; Alwin Eurick, Vice-President, Fund for Adult Education; J. R. Van Pelt, President, Michigan College of Mining and Technology; W. Kenneth Davis, Director of the Division of Reactor Development, AEC.
5. Thursday, June 20, 2:00 P.M. Committee on International Relations Conference.

6 Friday, June 21, 9:30 A.M. Institutional Representatives meeting of ECAC.

Report of

THE ENGINEERING COLLEGE RESEARCH COUNCIL

RAYMOND J. WOODROW

Chairman

During the year 1956–1957, the Engineering College Research Council has continued in a variety of ways to assist and promote engineering research in colleges and universities. As usual, these activities have been primarily along the lines covered by the various ECRC committees.

Relations with the Federal Government

During the year the Committee on Relations with the Federal Government of ECRC, under the chairmanship of H. R. Warfield, has considered and submitted comments on drafts of portions of the Armed Services Procurement Regulations which pertain to research and development contracts with educational institutions. In addition, the proposed U. S. Air Force facilities contracts have continued to be of concern. However, the primary efforts of the Committee have been devoted to the question of the determination of costs, particularly indirect expenses (or overhead), in contracts between the federal government and educational institutions.

At the 1956 Annual Meeting, the Engineering College Research Council approved, upon recommendation by the Committee on Relations with the Federal Government, a resolution to the effect that the methods of accounting for both direct and indirect costs of research in engineering colleges and universities must recognize and be adapted to the principles and practices which are followed in carrying out both teaching and research. This resolution was transmitted to various agencies of the federal government, but was primarily directed to a new intergovernmental committee headed up by representatives of the Bureau of the Budget, General Accounting Office, and the Treasury. This Committee had been established to prepare on a government-wide basis, a set of principles for the determination of costs under government research and development contracts and grants with educational institutions. These principles, when finally adopted, are expected to replace the so-called "Blue Book" or "Mills formula" which had been originally developed in 1947 for use in contracts from the Department of Defense.

During the year, representatives of the Committee on Relations with the Federal Government met with representatives of the Intergovernment Committee to discuss these new principles and related problems. At the year's end, the Committee had received the first draft of the Intergovernment Committee's new set of principles and was preparing to distribute these for comment. Arrangements had also been made to work closely with, and to coordinate results with, a Committee of the American Council on Education and a Committee of the National Federation of College and University Business Officers who are also active in the same field.

Relations with Industrial Research Agencies

This Committee, under C. A. Dunn, has concerned itself during the year with two important objectives. The first of these was the development of a general statement of policy which might be adopted by industrial organizations with regard to research which they sponsor and finance at an engineering college. The second objective is similar to some of the work done by the Committee on Relations with the Federal Government and is aimed at the improvement of the terms and conditions of contracts and grants from industry to the colleges. In order to achieve this second objective, a survey has been made of various types of research agreements which member institutions of the Council have used in connection with industrially sponsored research.

Research Administration

The Committee on Research Administration under H. W. Barlow is concerned with various aspects of internal administration of research in engineering schools. During the year, it has paid particular attention to the vital problem of engineering college salary administration problems which affect engineering research. A special afternoon session at the annual meeting for 1957 has been devoted to this topic with presentations by three different speakers. Special efforts were also made to have Presidents, Institutional Representatives, Deans and Directors of research attend this session.

Research Capabilities in Engineering Colleges

This Committee under the chairmanship of Eric A. Walker completed its preparation by the end of the year for the survey of research capabilities of engineering colleges being financed by a $40,000 grant from the National Science Foundation. The Committee decided that the desired results could only be obtained by personal interviews of representatives of all of the engineering colleges being surveyed. Questionnaires to serve as outlines for these interviews were developed and samples tested on several institutions. Interview teams had been selected and were in the process of training. It was expected that the bulk of the survey would be completed by summer's end.

Awards Committees

The Committee on the Vincent Bendix Award under the chairmanship of Ross J. Martin developed during the year a statement of qualifications and a selection procedure to be followed. Nominations were solicited, and a number were received for this award which was established a year ago to honor leaders in engineering education who have made outstanding contributions to the advancement of engineering research programs in colleges and universities. Dr. Theodore von Kármán was announced as the recipient, and was presented with the award at the ASEE Annual Banquet.

The Curtis W. McGraw Research Award Committee, under the chairmanship of J. R. Cudworth, developed a statement of qualifications and a selection procedure for this award which was presented in 1957 for the first time to recognize outstanding early achievements by an engineering college research worker under forty years of age. A number of excellent nominations for this award were re-

ceived and evaluated by the Committee. The award, which consists of a cash prize of $1000 and an accompanying engraved certificate, was also presented at the annual banquet to Dr. George Gerard.

Program for the National Meeting

The Program Committee under the chairmanship of J. D. Ryder had arranged an interesting program for the national meeting. At the general session sponsored by the ECRC, the theme stated was "Encouragement of Research and Graduate Programs Through the Efficient Use of Educational Manpower and Facilities." The topics discussed by the three speakers included research manpower, the organization and operation of a digital computer laboratory, and engineering science facilities.

This year the customary practice of having an ECRC session open to institutional representatives only has been somewhat modified and, as mentioned earlier, Presidents, Institutional Representatives, Deans and Directors of Research were then invited to attend a session on administration of research, at which particular attention has been paid to questions of engineering college salary administration.

The Council agreed this year to forego one afternoon session which it has usually had at the annual meeting, and which has normally been jointly conducted with another Division of the Society. This step was taken in order to cooperate with and support the important afternoon ECAC Conference sponsored by its Military Affairs Committee.

The pleasant custom of a joint dinner by ECAC and ECRC has been continued. The speaker for this year was Eric A. Walker, a past Chairman of ECRC and presently President of Pennsylvania State University.

Publications

During the year 1957 the Engineering College Research Review was prepared and put into publication, with copies available early in the summer. The Review this year has been expanded to include a history of the ECRC, in addition to the summary material covering the research conducted by each of the member institutions. Over one hundred million dollars' worth of engineering research is reported on in the Review for the ECRC member institutions.

Executive Committee

The usual four meetings of the Executive Committee were held during the course of the year. In order better to bring before the member institutions information concerning the activities of ECRC, it was agreed that copies of the Executive Committee minutes should be distributed to all institutional representatives. In addition, a brief summary of Executive Committee actions is being published in the JOURNAL.

The Chairman presented, at the invitation of the National Research Council, a paper describing activities of the American Society for Engineering Education and the Engineering College Research Council in promoting and fostering engineering research in colleges and universities. This was for the benefit of a visiting group of leading research managers and directors from Japan.

Nominations

The Nominating Committee, under Harold K. Work, presented names to

replace the following who have completed their term of office:

Kurt F. Wendt, Vice-Chairman
C. A. Dunn, Director (but elected to replace himself)
R. G. Folsom as Director

The complete list of officers, for the coming year, with the year of expiration of their terms of office, is as follows:

Raymond Woodrow, Chairman (1958)
F. C. Lindvall, Vice-Chairman (1958)
R. G. Folsom, Vice-Chairman (1959)
H. W. Barlow, Director (1958)
T. J. Killian, Director (1958)
J. R. Cudworth, Director (1959)
J. D. Ryder, Director (1959)
C. C. Chambers, Director (1960)
C. A. Dunn, Director (1960)
Renato Contini, Secretary

New Members

The following new member institutions have joined the ECRC during the past year:

Air University Institute of Technology
University of Wichita

REPORT OF THE TREASURER

JOHN GAMMELL

General comments regarding the estimated receipts and disbursements for the year 1956–1957 follow. The totals are based on actual entries to June 1 and an estimate of receipts and disbursements for the remainder of the fiscal year.

Receipts

1. As anticipated from the Third Quarter Report, the total receipts exceed the budgeted amount—by about $8000. The Pro-Forma Statement indicates $12,000 but $4050 of that amount needs to be allocated to a separate Summer Institute account.

2. Each item of income exceeds the budgeted amount, except miscellaneous account.

3. The total receipts exceed last year's receipts by about $8500 and last year's exceeded the previous year's by about $4000.

Disbursements

1. The total disbursements (excluding the Summer Institute item of about $1500 and about $2500 which must be pro-rated out of postage, telephone, supplies, salaries, etc.) almost equal the budgeted amount. This again is in accord with the indications of the Third-Quarter Report.

2. The JOURNAL showed the most significant increase over budgeted amount. Office secretaries' salaries were somewhat higher.

3. Items significantly less than budgeted amounts are Secretary's travel, Editor's travel, Council travel, ECAC, Contingencies and Special Projects, Utilities and CDEF.

Summary

1. The excess of receipts over expenditures is estimated to be about

$8000. Last year the difference was about $12,400.

2. It is recommended that the surplus to the nearest one thousand dollars be transferred from unappropriated surplus ($12,371.68 on July 1, 1956) to Reserve for Emergencies ($50,000 on July 1, 1956).

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Budget for 1957–58

General comments regarding the Budget follow.

Receipts

1. Individual dues—the amount is based on a net increase in membership of 350.
2. Institutional dues—the amount is based on a net increase of ten industrial members.
3. Publications—the amount is reduced slightly because there are no new publications.
4. Recruiting Practices and Procedures—no amount is included because if income exceeds the cost of printing more copies will need to be printed.
5. Refund from Annual Meeting—no amount is included because of uncertainty.

Disbursements

1. Annual Meeting—increased slightly to allow for greater distance of travel.
2. Journal and *Proceedings*—increased in accordance with established rates.
3. Increased to meet last year's expenditures.
4. Travel expense—officers—increased because of two additional vice presidents.
5. Travel—Council—reduced in accord with last year's expenditures.
6. ECAC—reduced in accordance with previous Executive Board action.
7. Salaries—increased in accordance with University of Illinois practice.
8. Bonding Fee and Audit—increased because 3-year payment of bonding fee is due.
9. Contingencies and Special Projects—reduced to balance budget.
10. Emergency reserve—added because of good budgeting practice.
11. Insurance, liability and Workman's Compensation—added as a result of previous Executive Board action.

THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Pro-Forma Statement for 1956–57 and Budget for 1957–58

Receipts

	Total 1956–57	Budget 1956–57	Budget 1957–58
Current Dues—Individual	$ 52,885.73	$51,800	$ 55,350
Institutional	14,539.50	13,600	15,050
Back Dues	1,780.00	1,600	1,700
Advance Dues	1,076.30	1,000	1,000
Subscriptions to Journal	2,695.27	2,353	2,500
Proceedings	559.00	300	400
Publications	1,794.63	654	1,200
Interest	3,174.24	2,694	3,300
Advertising	19,516.90	18,000	22,400
Sale of ECRC Publications	326.34	200	—
Miscellaneous	4.68	50	50
Teaching Ads	2,871.20	2,000	2,800
Recruiting Practices	251.58	—	—
Refund from Annual Meeting	533.08	—	—
Summer Institutes, AEC	4,050.00	—	—
Total	$106,058.45	$94,251	$105,750

PRO-FORMA STATEMENT FOR 1956–57 AND BUDGET FOR 1957–58—*Continued*

Disbursements

	Total 1956–57	Budget 1956–57	Budget 1957–58
Annual Meeting	3,218.25	3,000	3,500
Journal and Proceedings	38,000.00	34,000	38,000
Committees, Conferences and Divisions	1,252.00	2,000	2,000
Postage	2,059.48	1,300	1,700
Telephone and Telegraph	1,164.12	1,100	1,000
Supplies and Sundry Printing	3,655.92	3,000	3,300
Travel Expense—			
Secretary's Office	1,527.98	2,500	2,300
Officers	1,148.84	2,000	3,000
President	894.60	1,000	1,000
Editor	335.57	600	600
Council and Policy Committee	1,779.73	3,000*	2,000
ECAC	1,068.94	1,500	1,000
ECRC	4,350.00	4,350	4,350
Salaries—Secretary	7,902.12	7,902	9,155
Editor	3,190.32	3,190	3,745
Office Secretary (4)	14,031.50	13,380	16,360
Additional Office Secretary	381.77	936	3,600
Social Security	386.22	350	600
Retirement Emeritus	1,360.00	1,360	1,360
Bonding Fees and Audit (3 yr. 300–550)	600.00	500	850
Dues & Subscrip. American Council on Education	310.00	310	310
ECPD Contributions	680.00	600	680
Contingencies and Special Projects	636.78	2,000	841
EJC Dues	853.00	900	850
Miscellaneous	57.44	75	95
Utilities	396.38	575	500
Furniture and Equipment	605.00	475	100
Maintenance of Mechanical Equipment	109.80	125	150
Survey of Teaching English in Engineering Schools	453.72	500**	—
Committee on Development of Engineering Faculties	177.46	1,000**	—
Emergency Reserve	—	—	2,000
Insturance, Liability and Workman's Compensation	—	—	504
Summer Institute, AEC	1,539.99	—	—
Recruiting Practices and Procedures	450.00	—	—
President's Awards	300.00	—	300
Study of Engineering Profession	1,000.00	—	—
	$ 95,826.93	$93,528	$105,750

* Approved at June 1956 meeting.

** Added by Executive Board Action October 26, 1956. Taken from reserve for Special Projects; to be reimbursed when Project is financed and completed.

REPORT OF THE EDITOR

E. C. McCLINTOCK

(1) *Scheduling.* The principal occupation of the past year has been that of production—getting the *Journal* up to schedule. This has been substantially accomplished, though only by withdrawing two issues (December and January), with the permission of the Press, and having them done simultaneously elsewhere. The requested attempt to assist the deans by advancing the enrollment statistics section from the April to the March issue, however, lost some of the advantage, and production times have tended to slide again toward the end of the volume: May was presumably in the mails late in that month, and June went to press on June 3–4; it may even have reached you before the Annual Meeting departures, which is our definite aim for the future. The long lead time required for production and the slowness in actual completed deliveries are still major items to be negotiated, especially if it is not desirable for the Society to compact the issue schedule; we are pressing hard for improvement in these areas.

2. *Advertising.* In large part because of a serious price increase (10–30%) in printing charges imposed in mid-year as a result of higher labor costs, a revised advertising rate schedule (as attached) has been worked out and approved by the Executive Board for application with new contracts in the new volume. Our budget-balancing function for the Society requires that we also expand advertising revenue considerably, and this is our current top-priority added task. The *Journal* is being listed for the first time with Standard Rate and Data Service, and it is hoped that both individual and associate institutional members will support the Society advertising-wise.

3. *Content and Interest.* As the next step in development after production and advertising, we would like to check *Journal* planning and treatment against reader-member comments and wishes to insure the best selection and use of material for Society needs. With the encouragement of the Public Relations Committee, means of conducting such a survey are being explored to determine the relative value and correct proportioning of official materials, reports, Annual Meeting papers, contributed articles, special features, and news items. A few features have already been scheduled; some evidence of public interest is listing of the *Journal* by Documentation service for industry review, and by *Reader's Digest* and other publications for possible reprinting and reference.

Your direct comments and your investigations by interview with your various constituencies will help us in this effort to increase interest and appeal. Some progress seems to have been made, as it has in format and appearance, but we hope to do much more. Budget and time limitations are both severe, however; we welcome your continued aid, direction, and support, and appreciate what you and the Society membership have all been so kind in doing thus far.

MECHANICS DIVISION BULLETIN

Chairman's Message

DWIGHT F. GUNDER

Consultant
Loveland, Colorado

In order to combine a greeting to the members of the Mechanics Division of ASEE with a few remarks on my hopes for the coming year, I am going to state briefly my estimates of the principal weaknesses of practicing engineers who have graduated from American or foreign universities. To me these weaknesses are, in approximate order of importance:

1. *Failure to apply correctly the fundamental principles which have been taught to them.* Although this is occasionally a result of carelessness, it is usually a failure in understanding. Such basic and simple concepts as the laws of motion are consistently misused. Frequently the misuse comes through failure, or inability, to draw an accurate free-body diagram which states the problem under consideration. It is interesting to note that my observation is that foreign-trained engineers are at least as bad in this respect as are American-trained ones. This may be the result of the fact that while foreign engineers seem to have a more fluent knowledge of engineering in that they can reproduce formulas and theorems verbatim with little hesitation, at the same time, their understanding of the limitations of these formulas and theorems is just as spotty as is that of their American counterparts.

2. *Failure to design according to the basic principle of simplicity.* This frequently results in ridiculously complicated designs of machines and processes which are both difficult to fabricate and unreliable in use. It is believed that this weakness is really a function of weakness (1). Too often complicated systems and processes result from overly tight tolerances which only reflect a lack of understanding of the function which is to be performed.

3. *Failure to manipulate mathematics accurately.* This is a troublesome, but not usually fatal, weakness in that such errors are usually caught by coworkers. Furthermore, we use engineers in rather extensive duplication on each job so that this more or less routine portion of the work is frequently checked. This is in contrast to the errors in basic concepts mentioned in (1) above.

Strengthening the Weaknesses

It is my belief that rather large strides can be made in strengthening the weaknesses enumerated above. This can be done both in schools and industry. A few brief suggestions are made without elaboration.

First, greater emphasis should be placed upon understanding of basic concepts in the educational program. This can be done by solving fewer problems in a much more thorough fashion, including careful statements of principles at the time they are applied. This would result in the solution of problems in a manner which would seem quite new. Actually, the

emphasis would be upon stating *what* was being done and *why* it was the correct thing to do, rather than upon the manipulations which are required to proceed from the principles to the solutions.

Secondly, the mathematics which students learn should be used more in subsequent engineering courses than is now the case. We are making progress in this but, unfortunately, it frequently takes a generation or more from the time mathematical material is introduced into the curriculum for the entire teaching staff to become familiar with it. When new material is introduced into the curriculum, the entire teaching staff should become thoroughly familiar with it to assure its application in upper class courses.

It is my hope and belief that we can use the above suggestions as guides in our thinking during the coming years, and in particular, as guides in the consideration of the follow-up committee reports on the mechanics of solids, mechanics of fluids, and properties of materials.

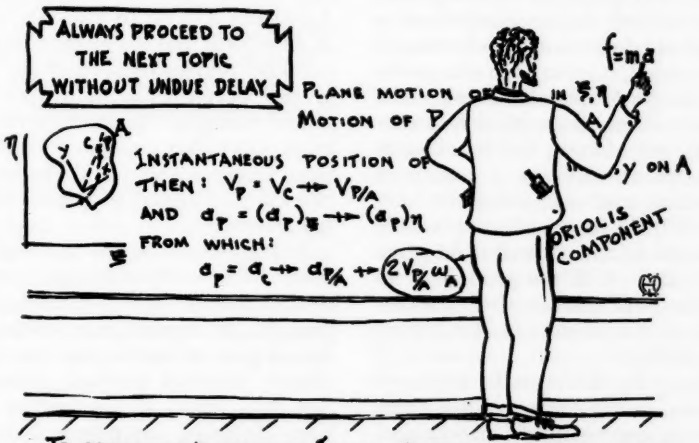
Good luck in the coming year.

EXECUTIVE COMMITTEE

D. F. Gunder, Ch.	1958
H. F. Marco	1958
P. F. Chenea	1959
R. L. Flanders	1959
F. L. Singer	1959
A. Higdon	1960
L. A. Smith	1960
D. R. Carver	1961
J. O. Smith	1961

Secretary of the Mechanics Division: Major Vincent S. Haneman, Jr., Department of Aeronautical Engineering, Air Force Institute of Technology, Wright Patterson AFB, Ohio.

Editor: Arthur W. Davis, Department of Theoretical and Applied Mechanics, Iowa State College, Ames.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AND $a_P = (a_P)_\xi + (a_P)_\eta$
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$a_P = a_C + a_{P/A} + (2V_{P/A}\omega_A)$
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TO CONCLUDE KINEMATICS I HAVE SKETCHED THE DEVELOPMENT OF THE CORIOLIS COMPONENT. SINCE THIS IS OBVIOUS, WE PROCEED WITHOUT FURTHER DISCUSSION TO KINETICS.

Professor Z. Freebody Snafu

REMARKS ON THE INTEGRATION OF SUBJECT MATTER

DWIGHT F. GUNDER

Consultant
Loveland, Colorado

Presented at the joint meeting of the Mechanics, Mathematics and Physics Divisions of ASEE at Cornell University, June 1957. Recommended for publication by the Mechanics Division.

It has been suggested frequently that certain subject matter in the engineering curriculum might well be integrated to save time, duplication of effort, and perhaps even confusion, while at the same time improving the motivation of the students. Courses considered amenable to the process of integration are variously suggested but usually include certain parts of mathematics, physics, mechanics, materials, elementary circuit theory, chemistry, and drawing.

Like most problems in integration which confront the engineer, there is no clear-cut decision as to what should be integrated, or even as to what process of integration should be used. The problem seems, then, directly analogous to determining the function to be integrated, choosing a process of integration, and evaluating the integral. Will the function be expressible in analytical form, or will it be given empirically? Will the process of integration be a numerical approximation, or will an answer in closed form be available?

Judging by the remarks so far in this joint session there is little likelihood that the function (subject matter) to be integrated can be defined precisely. Assuming this to be the case, we must then consider what process of integration is possible. A few such possibilities suggest themselves:

1. Integrate the *teaching* of the material rather than the material itself. This is done to varying degrees in almost every institution and, as we all know, its success is pretty much a function of the individuals involved and of their ability to keep an integrated teaching process in motion. Usually this type of integration needs periodic rejuvenation.

2. Integrate the *material* but retain the present classical subdivisions. Again this is done to a certain extent in all schools and the method requires periodic rejuvenation, perhaps to a greater degree even than does integrated teaching. Integrating the material puts rather cramping restrictions upon teachers who would like to exercise the very desirable trait of individual initiative.

3. Integrate *material* and *teaching* both. This method involves a quite drastic change from the classical approach. It requires new books, and to a degree at least, it also requires a slightly different teacher. Since the first two levels of integration have been discussed extensively before, I will devote my remarks to some of the possibilities of this third approach.

During the past three years it was my pleasure to try out a possible in-

tegration of both material and teaching. This was done at Cornell with the cooperation of the College of Engineering and, in particular, with that of Director Rhodes of the School of Chemical Engineering, who permitted us to try out some unusual approaches with two sections of his entering freshmen. I was fortunate to have also the cooperation and help of Professor Derald A. Stuart, Mr. Albert E. Seames, and Mr. Norman F. Toda, all of the Department of Mechanics and Materials at Cornell. Many other staff members both in and out of the College of Engineering made helpful suggestions and criticisms.

What we did was in no sense an experiment with appropriate controls. It was strictly what might be called a feasibility test. The subject matter chosen for integration was:

Mathematics through elementary differential equations,
Most of the topics from a standard college physics course,
Statics, dynamics and strength of materials (vector notation used),
First course in materials testing,
First course in basic electrical engineering.

It was proposed to replace these by:

A single course (6 credits per term for two years) in Engineering Fundamentals,
A one year course in mathematics (in the mathematics department) in the third or fourth year of the curriculum,
A one year course in physics (in the physics department) in the third or fourth year of the curriculum.

The above integration seems self-explanatory except perhaps for some details of the teaching and presentation method for the course in Engineering Fundamentals. It is not possible to more than indicate the approach here. First, the course was organized in two lectures, two recitations, and two laboratory periods per week, with one laboratory period usually reserved for a computing session. The emphasis throughout the course was on coordination of effort in lecture, recitation, and laboratory.

A strong effort was made to impart a physical concept to the mathematical procedures. The limit process, for example, was introduced through the analysis of a standard tension test in which it was necessary to find the slope of a curve. Appropriate notation was used in the laboratory with Δx, Δy, Δs, etc. being used for recording increments of load, stress, strain, and the like. Subsequent to this introduction (covering the first three or four weeks and including, of course, a good deal of other material), the rigorous definition of a derivative was presented as usually given in the calculus.

My only remark as to the effectiveness of this approach will be to state that on the day that the definition of a derivative was to be presented in the lecture, I found that a fair portion of the class had not only read this material in the text, but had been able to read it critically enough to find errors in the equations illustrating the details of finding a derivative by the limit process. Having taught this material many times in standard calculus courses, I was both amazed and delighted at this unexpected result. Throughout the course this type of occurrence was not uncommon.

Since this was only a feasibility check, no real evaluation of the results

should be attempted. Some comments can be made which have at least some basis in objectivity. Of the class of thirteen who entered the first section, six were still in chemical and metallurgical engineering, two had transferred to civil engineering, one to mechanical engineering, and one to arts, while three had been dropped for scholastic failures. Each had completed two and one-half years of the curriculum. Of the class of twenty-two who entered the second section, nine were still in chemical and metallurgical engineering, two were unclassified, three were in other schools of engineering, one was in agriculture, three had withdrawn from school and five had been dropped for scholastic failures. Each had completed the third semester of his curriculum.

One group was definitely more successful and the other somewhat less successful than the remainder of the students in the corresponding classes. Various reasons might be guessed for the difference. It is my belief that the most significant fact is that integration of material in this way is feasible.

This in itself does not lead us anywhere unless we consider some of the associated values. For example, students taking the course in engineering fundamentals have completed both statics and the first course in strength of materials by the end of their freshman year. This does not mean that they have had a smattering of these subjects, but rather that they have covered the complete course content with equivalent, and in many cases the same, examinations. The advantage of this approach for students of civil or mechanical engineering is that they may then enter the courses in structures, machine design, etc. at least one year earlier than normally.

The material in electrical engineering was planned for term three but later changed to term four since there were no electrical engineering students involved. Had it been presented as originally planned, the electrical enginering students would have been ready for their second course in circuits in the fourth term of their curriculum. It is also believed that a second major advantage accrues from the opportunity of the students to take more mathematics and physics in those departments *after* they have had some engineering background and have realized the need for and meaning of the material.

There are, of course, many problems to an approach such as this. After trying it out I am convinced that it represents a better approach, both from motivation and comprehension standpoints, than does the classical method. Furthermore, it opens rather broad opportunities for early introduction of engineering material in the curriculum, and for additional mathematics and physics near the end of the curriculum.

66TH ANNUAL MEETING

University of California, Berkeley

JUNE 16-20, 1958

INTEGRATION OF SUBJECT MATTER AT MICHIGAN STATE UNIVERSITY

CHARLES O. HARRIS

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Presented at a Joint Conference of the Mechanics, Mathematics, and Physics Divisions, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 20, 1957.

To our notion, integration of subject matter must be approached as areas of knowledge rather than as departmental names, and the entire curriculum must be taken into account. It is our concern that the engineering student have an opportunity to learn the essential principles which underlie the engineering of today and the future, and the question of which department teaches this material is entirely secondary. With these views, any significant attempt at integration of mathematics, physics, and mechanics must consider far more than the subjects commonly taken in the sophomore year.

Questions

In examining proposed changes of curricula, we can ask ourselves certain questions. These might be:

1. Has the relative significance of a particular subject matter changed in the last few years?
2. Is some new topic of so much importance that it absolutely must be included in the curriculum?
3. Are there new factors which require greater mathematical preparation for the student?
4. How can we best recognize and take full advantage of the fact that engineering thinking and engineering faculties are becoming steadily more scientific?
5. How do we insure that the net result is a gain, when changes become necessary which require that we devote less time to one subject in order to accommodate another?

Actions

There appear to be these significant items as recent steps toward integration in the College of Engineering at Michigan State University:

1. The Mechanical Engineering curriculum no longer includes the first two courses in sophomore physics, mechanics, heat, electricity, and magnetism; this is a loss of *8* quarter-credits. However, the Mechanical Engineering curriculum does include *18* quarter credits in mechanics; *21* quarter-credits in thermodynamics, heat transfer, and gas dynamics; and *9* quarter-credits in circuit fundamentals and electronic fundamentals, a total of *48* quarter-credits.

From the experience of one quarter, an interesting result is that the grades earned in statics by Mechanical Engineering students who had not studied mechanics in a physics course, showed no appreciable difference from the grades earned by Civil Engineering students who *had* studied mechanics in a physics course. No particular change was made in the teaching of statics to these students, who were mixed in the classes, although it was

noted that the Mechanical Engineering students had some difficulty in the early part of the course.

2. The Electrical Engineering curriculum no longer includes the sophomore physics course in heat, electricity, and magnetism; this is a loss of *4* quarter credits. It does include a course in thermodynamics in the department of Mechanical Engineering; and the sequence of courses in Electrical Engineering has been completely reorganized, with a more scientific orientation than before.

3. A *3* quarter-credit course in differential equations is now required in all undergraduate engineering curricula, and has been made a prerequisite for dynamics; this is a gain of *3* quarter-credits for most of the curricula. It also makes possible a better course in dynamics, a factor which certainly represents a gain, even though it is not feasible to evaluate it in terms of quarter credits.

4. Four of the six undergraduate curricula now include a *3* quarter-credit course in nuclear physics, and it is anticipated that a fifth will add such a course in the near future; the sixth curriculum includes a two-term course in modern physics. Here is a gain of *3* quarter-credits for most of the curricula. More important, however, than the gain in credits is the inclusion of this very important subject matter in the curricula.

As soon as adequate text material is available, it is very likely that we will go to a vector treatment in statics and dynamics. Current thinking is that we will ask the Department of Mathematics to include some vector algebra and vector calculus in the freshman and sophomore courses in mathematics.

It appears to be worth repeating that we must consider the entire curriculum in our thinking about integration of subject matter, must always be conscious of the fact that conditions change, and must free ourselves of any restrictions which might be imposed by what has been tradtional in departmental organization.

TIMOSHENKO HONORED BY ASME

Professor Emeritus Stephen P. Timoshenko of Stanford University has been honored by the establishment of a new award, the Timoshenko Medal. It will be presented for the first time to the man who inspired it, at an annual meeting banquet of the American Society of Mechanical Engineers in New York City December 4, 1957.

The medal is to serve as recognition of "distinguished contributions to applied mechanics." It will be awarded without restriction as to nationality or profession.

A member of ASEE since 1947, Professor Timoshenko was Twelfth Recipient of the Lamme Medal in 1939, and has won, among others, the Worcester Reed Warner Medal and the James Watt International Medal.

INTEGRATION OF SUBJECT MATTER AT BROWN UNIVERSITY

D. C. DRUCKER

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Presented at the joint meeting of the Mechanics, Mathematics and Physics Divisions of ASEE at Cornell University, June 1957. Recommended for publication by the Mechanics Division.

The question of desirability always implies a difference of opinion and often, as in this case, strong controversy. There is nothing more stimulating to a teacher than a good intellectual argument. To insure that it develops, let me leave its provocation for the closing remarks and start instead with practicality. Here the ground is firmer and statements can be measured and evaluated against physical reality.

Can mathematics, physics, and mechanics be presented to students in an integrated manner, although three or more independent departments are involved? Clearly the answer is yes if men of good will cooperate. The only problem, then, is how to avoid unnecessary duplication. All will agree that some repetition is essential in the educational process. It should, however, be conscious, and done with full knowledge and appreciation of what was said before, if the student is to derive the maximum benefit.

How can the desired objective be accomplished? Many possibilities exist, and each school must develop the best solution within its own constraints. The easiest way to describe what is tried at Brown is to first outline the curriculum of the standard four-year Sc.B. engineering program. Following a tradition established in 1920, all students (aeronautical, civil, electrical, and mechanical) take exactly the same program and are not segregated in any way in the individual courses of the first three years.

Sc.B. ENGINEERING CURRICULUM

Semester I	*Semester II*
General Chemistry (C 17)	General Chemistry (C 18)
Introduction to Engineering (E 3)	Introduction to Engineering (E 4)
English Composition or Elective	English Composition or Elective
Anal. Geom. and Calculus (M 9)	Anal. Geom. and Calculus (M 10)
Semester III	*Semester IV*
Vector Dynamics (E 7)	Electricity and Magnetism (E 38)
Differential Equations (M 29)	Fluid Mechanics (E 52)
Radiation Physics (P 61)	Mechanics of Materials (E 58)
Elective	Elective

Semester V	*Semester VI*
Electric Circuits (E 39)	Electrical Machinery (E 40)
Mech. of Matls. and Th. of Structures (E 59)	Physical Metallurgy (E 82)
Thermodynamics (E 71)	Thermodynamics (E 72)
Elective	Elective
Semester VII	*Semester VIII*
Engineering Option	Engineering Option
Engineering Option	Engineering Option
Free Elective	Free Elective
Free Elective	Modern Physics (P 62)

NOTES:

E denotes a course taught by the Division of Engineering, C by the Department of Chemistry, M by the Department of Mathematics, and P by the Department of Physics.

Courses labelled, Elective, as distinguished from, Free Elective, must not be chosen from the Physical Sciences group. A minimum of two must be selected in the Humanities and two in the Social Studies groups.

Engineering Economy must be chosen as a Free Elective unless a course in Economics has been taken.

We have imposed two very important constraints upon ourselves at Brown. One is the four-course plan. Each student at the University takes four courses each semester, and each course is of equal weight in terms of total demand on the student's time. There is no room for waste. One course is $\frac{1}{32}$ of the student's entire program, and $\frac{1}{18}$ of all the engineering, mathematics, and science courses taken in the first three years. Every topic must be examined carefully. Is it essential? Has it been covered before? Should it be covered again? Will it be treated later?

The other constraint derives from the very fast pace of the program, which is essential in order to give broad coverage and to reach the desired level in four years. For example, a vector point of view is adopted in dynamics to provide a proper background for the courses of the second semester of the sophomore year which follow.

A first-year physics course of the conventional type clearly is impossible in such an arrangement. The usual overlap and duplication with engineering mechanics, with electricity and magnetism, with fluid mechanics, and with thermodynamics would be inexcusable. Waste of classroom time alone would be bad enough, but calendar time as well would be lost, and most of the courses of Semester IV would have to be moved to Semester V. The student would be deprived of an appreciable portion of his educational gains.

Discarding first-year physics does not imply that the valuable point of view of the physicist is slighted. It is integrated with that of the engineer and presented in the relevant engineering courses. Physics texts, therefore, are often employed for large portions of such a course. Radiation physics, on the other hand, is given to our sophomores by physicists, as is modern physics, a required senior

course on a reasonably high level. Integration works both ways and the latter course contains a brief discussion of some technological aspects of nuclear reactors. Physical metallurgy with its strong emphasis on the physics of solids is taught in engineering and coordinated with the modern physics course to eliminate needless duplication.

The tightness of the program requires equally careful attention to mathematics. It is not possible to schedule more than three required courses in mathematics. Analytic geometry, calculus, and simple ordinary differential equations are covered. The vector algebra needed for vector mechanics is covered in the freshman year in Engineering 3–4, our omnibus introduction to engineering.

This course also covers vector statics and the basic elementary concepts of both statics and dynamics. Following the mathematics courses in the first three semesters, the study of ordinary differential equations is continued through mechanics of materials and structures, and electric circuits. The study of partial differential equations must begin in fluid mechanics, as must also the study of complex variables and functions. The latter is continued in the electric circuit course, and the former, in thermodynamics. Vector calculus is given in both fluid mechanics and in electricity and magnetism.

The approach to mathematics in the engineering courses is neither of the cookbook school nor that of modern mathematicians where much attention is paid to rigor. Rigorous proofs are sometimes sketched by reference to the mathematics courses taken earlier, and the absence of rigor is noted when appropriate. Although some attention is paid to matrices in the first three years, the more advanced topics in matrices, in ordinary and partial differential equations, including Laplace and Fourier transforms and special functions, are left to the courses of the senior year.

Conservation of the student's time requires integration within engineering as well. Vibrations, for example, cannot be treated as a separate required course in the first three years. All students get a foundation in the subject through its treatment in dynamics, in mechanics of materials, in structures, and most important, in electric circuits. The electro-circuit mechanical analogs are derived and described, and the appropriate mathematics is developed. Similarly, although both Engineering 38 and 52 introduce and use vector calculus, at present 38 emphasizes the integral and 52, the differential operators. As another example, the study of compressible fluid flow is continued in thermodynamics.

Through careful integration of subject matter the student is able to progress more rapidly on a firm foundation. Topics in mechanics of solids, such as St. Venant torsion, thick-walled tubes, membranes and plates, and vibrations of continua can be, and are, covered in required option courses in the senior year. The general theorem of virtual displacement, the usual specialized energy theorems, and the fundamentals of limit analysis and design are studied by all students in the junior year.

Now we can return to the question of desirability. Is it desirable to integrate all programs of study? In the liberal arts there is much to be said for almost complete freedom of action. Coverage of specific topics is of

little importance. Most of the sequential aspect which is characteristic of science and mathematics is missing in the humanities at the undergraduate level. Depth of understanding is possible at different levels of knowledge. The more deep exposure to different points of view the better for the student.

Is this last point not valid for engineering students also? Wouldn't it be easier to forego integration in an engineering program? Why struggle to make every part of every course count? Why not have six or seven courses each semester, as so many schools do, and repeat all the material that engineers and particular engineering options need? Haven't we often heard civil engineers complain about the mechanics taught to their students by the mechanical engineers, and vice versa?

The advantage of a complete and thorough integration is enormous, however. After all, each student can spend no more than a reasonable quota of hours per week, say 55 to 60. It is of no consequence in this connection whether the number of courses he takes is 4 or 5 or 6 or 7. Each wasted course or part of a course is subtracted from his available time. A decreased coverage of subject matter is inevitable. Even worse, and more important, without the most careful scrutiny, the tempo of the curriculum slows down and the level which can be reached by the student drops by a significant amount.

Certainly integration is difficult and requires the constant attention and best efforts of all staff members. It is hard to teach a course looking forward and backward at the same time, and to achieve agreement with several groups in overlapping fields every time a major change is to be tried.

Nevertheless, in principle and on paper, there is the possibility of integrating a hundred separate courses or a thousand individual lectures. In practice, we all recognize that this would prove impossible. The optimum number must be a compromise in the best interests of the student. We at Brown feel that we are reasonably successful in coordinating the courses of the first three years under a four-course plan.

Such a continual agonizing reappraisal of each course in the light of all others has the obvious effect of preventing stagnation. Interest in the curriculum runs high and new ideas are debated eagerly. All members of the staff are quite well aware of the content and philosophy of the courses which precede theirs, and of the courses which will follow the ones they teach.

It is my feeling that coordination of five courses, although more difficult, would prove feasible in some semesters, but that six or more could not be handled. The natural and desirable tendency of a teacher for self-expression, the discouraging self-made walls of isolation separating members of the faculty with different interests, and the general difficulty with large numbers mitigates against success. Lack of communication and apathy cause trouble more often than disagreement on principle.

If four or perhaps five courses in some instances can be worked out, why not three? Surely the fewer the courses the greater the integration possible. If, however, the final level to be reached in the complete program is accomplished in the same calendar time, the fewer the number of courses per semester, the greater the progress which must be made in each course. Here a real stumbling

block is encountered. There does seem to be a limitation on the information and the concepts in any one branch of knowledge which can be absorbed by the student in a given number of months. We do feel occasionally that this is a difficulty even with four courses. With three courses this problem would be far more troublesome.

Conclusions

It is extremely difficult to devise a four-year curriculum which is truly worthy of the label of engineering today. The most careful integration of engineering, science, and mathematics is required in each year for the students to achieve both the broad coverage and the high level of knowledge desired.

If it is agreed that breaking up the curriculum into a multitude of two and three credit fragments presents unsurmountable problems of integration, then two steps must be taken. Engineers must teach those portions of physics which are now an essential part of engineering.

We must also teach, at a proper level, much of the mathematics needed by our students. This may well mean both dropping the conventional freshman physics course, and foregoing a required mathematics course beyond the introduction to ordinary differential equations. This is what we have attempted at Brown University.

ASME NUCLEAR CONFERENCE

A four-day discussion program on "The Mechanical Engineer in the Nuclear Industry" will take place during the annual meeting of the American Society of Mechanical Engineers, opening in New York City on December 2. Open to all interested persons, the meetings will take place at the Statler Hotel. Additional information can be obtained from F. D. Acker, Combustion Engineering, Inc., 200 Madison Avenue, New York 16, N. Y.

1958 NUCLEAR CONGRESS

Engineers Joint Council has announced that the 1958 Nuclear Congress will take place in Chicago, March 17 through 21, at the International Amphitheater, with headquarters at the Palmer House. Theme of the Congress is "Industrializing the Atom."

Newly declassified information will be made public at the Congress, which is now sponsored by 30 national groups. Copies of an advance program, published November 15, and additional information can be obtained from the Congress Manager, American Institute of Chemical Engineers, 25 West 45th Street, New York, N. Y.

Comments on

"ETHICS OF RECRUITING" CODES

W. LEIGHTON COLLINS

ASEE's *Recruiting Practices and Procedures* was prepared and published last year in a rush attempt to stem the increasing flood of unethical recruiting efforts by some companies. Since another code now is being widely distributed by the United States Chamber of Commerce, and the College Placement Council, it seems pertinent to review what ASEE has done in this area of recruiting practices in order to avoid confusion or misunderstanding.

ASEE had established its leadership in defining the ethics of recruiting practices as early as 1949 when it published *Ethics of Interviewing Procedures,* which was also endorsed by the Engineers' Council for Professional Development. For a number of years thereafter this code met the needs of students, colleges, and recruiters, but by the spring of 1956 it was apparent that an entirely new look needed to be taken at the ethical problems of recruiting. The shortage of engineers and the keen competition for their services had resulted in the development by some would-be employers of practices which needed to be stopped immediately.

Recognizing this trend, ASEE's Engineering College Administrative Council discussed the situation and asked for immediate action. The problem was referred to the Ethics Committee and the Committee, knowing that the problem was to be discussed at the September, 1956 meeting of the Midwest College Placement Association, withheld action until after that meeting. MCPA extensively modified ASEE's 1949 code and adopted the revision. This was then studied and modified by ASEE's Ethics Committee, in cooperation with MCPA representatives. In April, 1957 10,000 copies of *Recruiting Practices and Procedures* were published by ASEE for general distribution to colleges and industry.

ASEE's publication was just off the press when the Secretary of ASEE was informed by telephone of the interest of the Manufacturing Chemists' Association in such a publication, and the decision of the United States Chamber of Commerce to assist all other interested groups in the preparation and distribution of one "code" to prevent the publication of many. ASEE's *Recruiting Practices and Procedures* was requested for consideration and was made available by ASEE to form a basis for this new study in which the College Placement Council, representatives of regional placement associations, employers, and ASEE representatives participated. ASEE withheld seeking adoption by other groups and gave limited publicity to its original version, pending action by the Chamber-sponsored group.

The publication of the joint Chamber-Placement Council code, "Principles and Practices of College Recruiting," and its approval for release by the executive committees of the regional placement associations are indicative of the recent increased interest of industry and education in the ethics of recruiting. ASEE and its Ethics Committee welcome all inter-

ests in ethics and all efforts to hold interview and employment procedures at a high ethical plane. The publishing of the two codes is accomplishing much of what originally needed to be achieved.

The code printed on the following pages is the same as in ASEE's separate publication "Recruiting Practices and Procedures," and is printed in the JOURNAL in accordance with the general practice of making a permanent record of important actions of the Society.

RECRUITING PRACTICES AND PROCEDURES

A Report of the ASEE Committee on Ethics

Foreword

Industrial employers have actively competed for the services of engineering graduates in recent years. In the stress of the competition, certain employers have developed procedures in their dealings with students which do not appear proper to other employers, particularly to those employers who have been visiting colleges to interview seniors for twenty-five and even fifty years.

Complaints about those recruiting procedures came to a head at the June, 1956, meeting of ASEE. The problem was considered in a session of the Engineering College Administrative Council, and was thoroughly discussed in the business meeting of the Committee on Ethics. The Society's "Ethics of Interviewing Procedures," published in 1949, had been instrumental in solving similar problems of that time. The Committee on Ethics was accordingly of the opinion that the present difficulty might likewise be overcome, at least in part, by the formulation and publication of a revised code, adjusted to new conditions.

It was expected that the Midwest College Placement Association would meet late in September and that the interviewing problem would be discussed. The ASEE Committee on Ethics believed that it should not proceed with the formulation of a code prior to this meeting. Arrangements were made with the Midwest College Placement Association for representatives of the Committee on Ethics to attend the MCPA meeting. The Midwest College Placement Association not only reviewed the problems but revised the code for interviewing. This code was submitted to the ASEE Committee on Ethics.

In the meantime the Committee on Ethics reported on its operations, and its cooperation with and from the Midwest College Placement Association to the General Council of ASEE at its November, 1956, meeting. The Council authorized the Committee to proceed according to its best judgment in preparing for publication the final draft of the revised code.

The code prepared by the Midwest College Placement Association was submitted to the members of the Committee on Ethics and a number of changes were made in the code. The revised code was adopted by the Committee on Ethics under the authority given by Council and it is hereby published for the guidance of college faculties, placement officers, employers, and others concerned.

Employer Responsibilities

1. The employer should contact the Placement Office long in advance so that the college can plan to accommodate all employers who wish to interview. In his original request for an interview date, the employer should explain how he wishes to organize his interviews. Employers must keep in mind that only a limited number of corporations can interview on campus at a given time, and that the scheduling of interviews is difficult.

2. Within two weeks following the interview, the employer should communicate with the student concerning the outcome of the interview.

3. The employer should give the student ample time to consider his offer before requiring a final answer.

4. The employer should provide suitable literature to give students a true picture of the corporation. This material should be supplied to the Placement Office, or to the faculty if there is no Placement Office, in sufficient quantity and well in advance of the interview date. The interviewer should clearly explain to students what tests they will need to pass, and if there will be a physical examination. He should give students complete information concerning any special requirements such as the signing of patent agreements.

5. The employer should inform the Placement Office concerning the broad categories of employment available, and the college degrees and other requirements for each.

6. The employer should accept responsibility for permanent relations accept a particular employment offer. with the colleges. Hence he should conduct interviews year after year, or otherwise maintain contact with the colleges.

7. If the employer invites students to visit his plant or headquarters, he should arrange the visit to interfere as little as possible with class schedules. He should avoid elaborate entertainment and overselling. He should explain what expenses will be paid and how and when. (Many students borrow money to make these employment visits.)

8. The employer should send copies of all correspondence with students and faculty members to the Placement Office.

9. The interviewer should be punctual. He should tell the Placement Office when he will arrive, and he should arrive no later than the designated time.

10. No more than two and preferably only one interviewer representing an employer should appear for each interview schedule. Arrangements for more than two interviewers should be made well in advance, and only for reasons which are considered adequate by the Placement Office.

11. An employer who desires to contact a particular individual at the

time of his interview visit should write that individual at least two weeks in advance, with a copy to the Placement Office.

12. The employer should not offer a student special payments, gifts, bonuses, or other inducements, nor should he compensate or favor a third party to prevail upon the student to accept a particular employment offer.

13. After a student has declined a job offer, the employer should renew his proposal only through the Placement Office. The employer is thereby prevented from annoying students who have accepted employment elsewhere.

14. The employer should invariably engage every student who has accepted the company's offer.

15. If the employer's organization is unionized, or the department for which the student is to be engaged, is unionized, the employer should tell the student if he will or will not have to join a union. Furthermore, the employer should give the student complete and detailed information as to how the union will affect his status if employment is accepted.

16. When both a parent corporation and subsidiary or affiliated corporations conduct interviews in the same college, the respective interviewers should clearly explain their missions and their connections, both to the Placement Office and to the students. Interviewers should make clear where, and by which unit or division or subsidiary corporation, the students are to be engaged.

17. Interviewers should very carefully follow the interview schedule agreed upon with the Placement Office. They should not detain any student beyond the specified time.

18. The employer should not hurry a student into making a decision concerning employment.

College Responsibilities

1. The Placement Office should inform interviewers concerning the number of students available for interview in the several curricula, and the dates of graduation. This information should be sent as soon as it is available.

2. Placement Offices should not restrict the number of interviews per student, except that they should discourage indiscriminate "shopping."

3. The Placement Office should provide adequate space and facilities for quiet and private interviews.

4. The Placement Office should announce to students at the beginning of the school year which employers will interview students and when. The Placement Office should make revised announcements from time to time as may be necessary.

5. The Placement Office should arrange for interviewers to meet faculty members who know students personally and can provide information about their work and qualifications. Such contacts should be in school hours.

6. The Placement Office should make available to interviewers appropriate records of those students who are to be interviewed.

7. When an employer is looking for graduates in several fields, e.g., engineering, psychology, physics, the Placement Office should issue announcements to all students concerned, and schedule interviews for all those who express interest.

8. Placement officers may advise students, but should not unduly influence them in the selection of jobs.

9. Placement Offices should control distribution of company literature.

Student Responsibilities

1. The student should prepare properly for each interview by reading available literature, by informing himself about the employer in question, and by organizing his thoughts in order to ask and answer questions.

2. The student should use care in filling out various forms such as the standard "College Interview Form," in preparation for interviews.

3. The student should conduct himself in a businesslike manner during interviews.

4. The student should not "hoard" or "collect" job offers. As soon as he knows that he will not accept an offer, he should immediately decline it.

5. The student should not continue to present himself for interviews after he has accepted an employment offer.

6. The student should keep the Placement Office advised concerning his negotiations.

7. The student should *promptly* acknowledge invitations for visits to plants or corporation headquarters. He should accept invitations only when he is sincerely interested in an offer from the employer in question.

8. The student who visits an employer's plant or headquarters for an interview should include on his expense sheet only those expenditures which actually pertain to the trip. If he visits several employers on the same trip, expenses should be prorated between them.

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As of September 27, 1957

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BACHER, ROBERT F., Chairman of Physics, California Institute of Technology, Pasadena. F. C. Lindvall, D. E. Hudson. Divisional Interests: Educ. Admin., Physics, Math.

BARENBERG, ERNEST J., Instructor in Civil Engineering, University of Kansas, Lawrence. James T. Wang, David W. Appel.

BUHL, HAROLD R., Assistant Professor of Mechanical Engineering, Iowa State College, Ames. George K. Serovy, Robert C. Fellinger.

BURKE, THOMAS A., Director of Engineering, Merrimack College, North Andover, Mass. Gerald J. Kirwin, William F. M. Longwell. Divisional Interests: Educ. Admin., E. E.

CONNER, CLINTON L., Assistant to the Dean of Engineering, University of Colorado, Boulder. C. L. Eckel, Paul E. Bartlett.

COSTA, ARMAND J., Assistant Professor of Mechanical Engineering, University of Massachusetts, Amherst. Joseph S. Marcus, George P. Weidmann. Divisional Interests: Engr. Dwg., Shop & Mech. Arts.

ECKERT, CLARENCE A., Director, School of Installation Engineering, Air Force Institute of Technology, Wright-Patterson Air Force Base, Ohio. R. A. Seaton, LaVerne F. Lewis. Divisional Interests: Educ. Admin., Gen. Engr.

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FETTY, HOMER, Chairman of Technical Sciences, Los Angeles State College, Los Angeles 29. Divisional Interest: Educ. Admin., English.

GENZLINGER, BRYCE S., Assistant Professor of Industrial Engineering, Syracuse University, Syracuse 10. Bert H. Norem, D. U. Greenwald. Divisional Interest: Ind. Engr., Engr. Econ.

GIBSON, AUBREY W., Assistant Professor of Mechanical Engineering, Michigan College of Mining and Technology, Houghton. Frederick E. Witty, Marion W. Hughes.

GOLDEROS, ALFONSO, Assistant Professor of Civil Engineering, University of Puerto Rico, Mayaguez. H. Marti-Marini, F. Gonzales-Mandry.

GUINDON, WILLIAM G., Chairman of Physics, Boston College, Chestnut Hill 67, Mass. Brother A. Leo, A. Del Vecchio. Divisional Interest: Educ. Admin., Physics.

GULICK, LEE N., Professor of Mechanical Engineering, University of Pennsylvania, Philadelphia 4. Carl C. Chambers, Paul R. Trumpler. Divisional Interest: Shop and Mech. Arts, Ind. Engr.

HALL, MAYNARD E., Associate Professor of Engineering, West Virginia Institute of Technology, Montgomery. L. C. Nelson, G. C. Sloven.

HINKLE, CHARLES N., Associate Professor of Agricultural Engineering, South Dakota State College, Brookings. Dennis L. Moe, Herbert F. Marco. Divisional Interest: Agr. Engr.; C. E.

HINKLEY, J. WILLIAM, President, Research Corporation, 405 Lexington Avenue, New York 17. Joseph W. Barker, R. L. Woodrow. Divisional Interest: Educ. Admin., Ind. Engr.

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Chas. C. Cavalconte. Divisional Interest: Educ. Admin., Maths.

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KELLY, GEORGE E., JR., Instructor in Electrical Engineering, Prairie View A. and M. College, Prairie View, Tex. Frederick M. Graham, C. L. Wilson. Divisional Interest: E. E., Math.

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SJOGREN, CLARENCE A., National Secretary and Editor of Sigma Tau, Lincoln 10, Nebraska (Reactivating lapsed membership).

SMALLEY, HAROLD E., Associate Professor of Industrial Engineering, University of Pittsburgh, Pa. A. G. Holzman, E. A. De Leo. Divisional Interest: Ind. Engr.

SPITLER, EVERETT E., Instructor in Mechanical Engineering, Purdue University, West Lafayette, Ind. O. C. Cromer, Daniel J. Schleef. Divisional Interest: Mech. Engr., Math.

SPOKES, ERNEST M., Professor of Mining Engineering, University of Kentucky, Lexington, Ky. C. S. Crouse, Sam C. Hite. Divisional Interest: Mineral Tech., Metall., Min.

SPROUL, OTIS J., Assistant Professor of Civil Engineering, University of Maine, Orono. W. S. Evans, Frank M. Taylor. Divisional Interest: C. E.

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Divisional Interest: Ind. Admin., Bus. Admin.

STATT, CYRIL J., Manager of Manufacturing Engineering Department, General Electric Company, New Hartford, New York. C. L. Foster, N. E. Vilander. Divisional Interest: Ind. Admin., Tech. Inst.

STIFF, ROBERT S., College Relations Representative, Personnel Department, Chance Vought Aircraft, Incorporated, Dallas, Tex. C. A. Besio, W. D. Hill. Divisional Interest: Ind. Admin., Coord. of Coop. Engr.

SULLIVAN, JAMES F., Chairman of Electrical Engineering, Merrimack College, North Andover, Mass. William F. M. Longwell. Gerald J. Kirwin. Divisional Interest: E. E., Ind. Engr.

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VAZQUEZ, AGRAIT W., Assistant Professor, College of Agriculture and Mechanic Arts, Mayaguez, Puerto Rico. H. Marti-Marini, F. Gonzales-Mandry.

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WATKINS, JOHN T., Associate Professor of Civil Engineering, Rensselaer Polytechnic Institute, Troy, N. Y. John M. Beatty, J. Sterling Kinney. Divisional Interest: C. E.

WEYHER, THEODORE A., Dean, School of Engineering, University of Miami, Coral Gables 46, Fla. J. H. Clouse, Cecil P. Marion, Jr. Divisional Interest: Educ. Admin., Mech. Engr.

ZIMMERMAN, FRANCIS J., Assistant Professor of Mechanical Engineering, Yale University, New Haven 10, Conn. Newman A. Hall, Frederic W. Keator. Divisional Interest: M. E., Physics.

50 New members
100 Previously added

150 New members this year

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